A TEXT-BOOK OF WEST AFRICAN AGRICULTURE

SOILS AND CROPS

BY

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31117

14 SEP 1934

FEB 2008

MAY 2003

OXFORD UNIVERSITY PRESS

LONDON : HUMPHREY MILFORD

1934

OXFORD
UNIVERSITY PRESS
AMEN HOUSE E.C. 4
London Edinburgh Glasgow
Leipzig New York Toronto
Melbourne Capetown Bombay
Calcutta Madras Shanghai
HUMPHREY MILFORD
PUBLISHER TO THE
UNIVERSITY

'Agriculture and handicraft are the foundations of civilization.'

ALBERT SCHWEITZER

PRINTED IN GREAT BRITAIN

TO
MY WIFE

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INTRODUCTION

This book was written primarily for Africans, as an aid to students taking Agricultural Science as a subject in the Cambridge School Certificate Examination. It is hoped that it will be of general use in Secondary Schools, Middle Schools, Training Colleges for Teachers, and in Agricultural Schools and Colleges. While its standard is quite beyond elementary schools, it should serve as a text-book or reference book for elementary school teachers.

The main objects of the book are to stimulate an interest in agriculture, to follow up practical work in school gardens, farms, and agricultural camps, and to lead students to study the complex and fascinating problems of scientific agriculture. Much can be done in the laboratory, in soil experiments, and in the making and examination of oils, fibres, and agricultural produce. As soil experiments are so fully worked out for school use in Sir E. J. Russell's *Lessons on Soil*, the teacher is recommended to use that book in conjunction with this.

The economic side of the subject is scarcely mentioned, since it presents difficulties as a school subject; so that traders and others who wish for help in that respect are recommended to read Faulkner and Mackie's *West African Agriculture*. This recently published and valuable book gives the result of years of experiments in Nigeria followed by brief practical details concerning the main cash crops grown in West Africa. In the present book, however, more emphasis has been laid on food crops, as at the present time in particular the growing of foodstuffs is vitally important. A companion volume on West African Foods and Home Science as a subject in Girls' Schools is badly needed.

Livestock and Poultry are not dealt with in this book, as it is hoped that some one will tackle these subjects in another work. Nor is there special mention of important subjects like Mixed Farming and Agricultural Co-operation. It is realized, in fact, that this book is very incomplete, but nevertheless it has been produced in its present form because nothing else of its kind for Africans existed hitherto. Criticisms and suggestions as to how the book can be made more useful will therefore be welcomed.

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January 1934

ACKNOWLEDGEMENTS

THE author is indebted to Messrs. Phillips, Dade, Cotterell and Greenwood of Aburi for help with the sections on Budding and Grafting, Plant Diseases, Insect Pests and Soils respectively. Mr. A. C. Miles of the Gold Coast Agricultural Department, Mr. R. H. Bunting, late of the Gold Coast, and Miss Hellins of Achimota have given valuable help with reading the proofs and making useful suggestions. Mr. T. Hunter, late of Kumasi, read the chapter on School Gardening, Mr. C. W. J. Line the chapter on Citrus Fruits, Dr. J. M. Dalziel of Kew the section on Crops, and Mr. I. H. Burkill the chapter on Yams.

Sir John Russell and members of his staff at Rothamsted Experimental Station have been of great assistance with the Soil section.

For photographs, the author is grateful to the following:

The Director of Agriculture on the Gold Coast for Plates III (*b*), XI (*a*), (*b*), XV, XVI, XVIII, XIX, XX (*a*), (*b*), XXI (*a*), (*b*), XXIII (*a*), (*b*), XXIV (*a*), XXXII (*a*), (*b*), (*c*); Mr. Smythe of the Nigerian Agricultural Department for Plates II (*a*), III (*a*); Mr. J. Steele of the Gold Coast Agricultural Department at Tamale for Plates II (*b*), VII (*a*), (*b*), VIII (*a*); Sir John Russell for Plates I (*b*), XXVIII (*b*); the Director of the Royal Botanic Gardens, Kew, for Plates XXV (*a*), (*b*); the Director of the Imperial Institute, London, for Plates IV, V, VI (*b*), XVII (*a*), XXX (*a*), (*b*); the British Cotton Growing Corporation for Plate XIV (*b*); Dr. H. G. Thornton of Rothamsted, for the reproduction of Fig. 3, from Technical Communication No. 20 *The Inoculation of Lucerne* (by kind permission of the Controller of H.M. Stationery Office); the Controller of H.M. Stationery Office for permission to reproduce Figs. 4 (*a*), (*b*), from Technical Communication No. 20.

The remaining photographs (Plates I (*a*), VI (*a*), VIII (*b*), IX (*c*), X (*a*), (*b*), XII (*a*), (*b*), XIII (*a*), (*b*), XIV (*a*), XVII (*b*), XXII (*a*), (*b*), XXIV (*b*), XXVI (*a*), (*b*), XXVII (*a*), (*b*), XXVIII (*a*), (*c*), XXIX (*a*), (*b*), XXX (*c*), XXXI (*a*), (*b*)) were taken by the author.

The diagrams have been drawn by Miss L. O. Deakin of Achimota (Figs. 11, 12, 13, 14, 15 (*a*), (*b*), 16 (*a*), (*b*), 17 (*a*), (*b*), 18 (*a*), (*b*), (*c*), 19 (*a*), (*b*), 20 (*a*), (*b*), (*c*), 21, 22 (*a*), (*b*), (*c*), (*d*), 23 (*a*), (*b*), (*c*), 25, 26, 27, 28, 29, 30, 31 (*a*), (*b*), 32); Miss M. J. Field of Achimota (Figs. 1, 2, 4 (*a*), (*b*), 5 (*a*), (*b*), (*c*), 6, 7, 8, 9, 10); Mr. R. H. Bunting (Figs. 3, 24), and Mr. J. S. Shaw (Fig. 33).

CHAPTER I

FORMATION OF THE SOIL

LIFE on the earth would be impossible without the soil, which is that portion of the earth's surface supporting plant-life, and on which all living creatures ultimately depend. The soil is only a very shallow layer, and it is only necessary to dig almost anywhere to realize what a shallow layer the soil is. Even this thin layer, often but 6 inches deep, has been formed only after millions of years.

The topmost layers are generally dark in colour. In some tropical soils they are quite deep. Below them there is generally a yellow, brown, or reddish layer which resembles soil in many respects. Sometimes it easily crumbles, although at other times it is composed of stiff clay. It contains few or no rootlets of plants, and is not dark in colour, like the soil at the surface. As it is found *underneath* the ordinary surface soil it is generally called *subsoil*. It is usually thicker than surface soil, and it is often difficult to see exactly where surface soil changes to subsoil. The depth and composition of the subsoil is important in tropical agriculture, as many tropical crops, such as cacao, oil and coconut palms, coffee, and other crops are perennial and send their roots much deeper than the surface layers.

It is obvious that soil is formed from the earth's surface, but inquiry into the composition of the earth itself leads to difficult questions of geography, of geology, which is the study of rocks and the earth's surface, and finally of astronomy, which is the study of worlds in general. Therefore the study of soil really begins with the study of worlds and their formation, and with the formation and composition of our own world in particular. Our earth originally came from the sun, and the moon came from the earth, so that they all had a common origin and are composed of the same materials, or 'elements' as they are called in chemistry. The sun is hot and the moon is cold, whereas the earth is neither so hot as the sun nor so cold as the moon. The moon, being the smallest of the three, cooled quickest, the earth next, and the sun, being many times larger than the earth, takes longest to cool and is still a flaming ball of gas. The sun in its turn is believed to have come from larger flaming masses of gas called *nebulae*, some of which, for instance the nebula in Orion, can be seen with a small telescope on a clear star-lit

The soil of the Canary Islands, for example, although comparatively thin and stony, is so rich that when water is brought to it by irrigation, wonderful crops of bananas and other plants can be grown. Similarly in Java, Sumatra, and other parts of the East Indies the islands are of volcanic origin, and some of the richest agricultural soil in the world is found there. Some igneous rocks, however, such as quartz, decompose to form very poor soils.

The cloudy vapour in the atmosphere surrounding the earth as it cooled, gradually condensed and fell as rain. The water found its way to the lower portions of the earth's surface, flowing as rivers in the mountain valleys and finally forming great lakes and seas in the lowest portions. As these rivers dashed rapidly downwards they wore away the surface of the rocks beneath them, carrying fragments towards the sea. In the upper reaches of the rivers, where the fall was great and the speed rapid, portions of rocks or boulders were loosened and fell into the streams and rivers. These were pounded by the rushing water, rolled over, broken into smaller particles which, in their turn, were rolled lower down the channel of the river. Their jagged edges were rolled over each other in the beds of the rivers until they became smooth and rounded by the wearing of the water passing over them. In the lower reaches of the streams these pebbles became gradually smaller, but the wearing process still continued until the particles become so small as often to be scarcely visible with the naked eye. This process still continues to-day, and is called *erosion,* the erosion caused by muddy or sandy water being much greater than that caused by clear water. The harder or sharper the particles carried by the water, the greater the erosion.

Much depends on the *speed* of the stream. A stream flowing at a rate of a quarter of a mile an hour will just lift fine sand, whereas a stream moving at two miles an hour will roll along angular stones the size of an egg. As the streams reach the lower valleys and their fall becomes less and their speed correspondingly slower, they drop the tiny particles or fragments of rock which they carried along with them. The larger particles are dropped first and the smaller ones later, as the valleys become wider and the speed of the rivers decreases. Sometimes floods occur and the rivers overflow their banks, such as the Nile does to-day in parts of Egypt, and as many rivers in West Africa do in the rainy season. The rivers spread out in broad

night. But a study of nebulae and their believed power of giving rise to new worlds belongs to the realm of pure astronomy and need not be followed here.

The earth, then, is much smaller and much cooler than the sun. The outer layer or *crust* has solidified and the greater portion of the interior is believed to be still hot and in a liquid form. We have evidence of this in *volcanoes*, where masses of molten matter, or *lava*, flow down their sides and finally cool and form rocks. From time to time rumblings take place beneath the earth's crust, owing to its cooling and contracting. These contractions set up pressure, and as a result violent earthquakes sometimes occur, generally in so-called 'volcanic' regions, where active or lately active volcanoes are found. In West Africa, fortunately, only slight earthquakes occur and no great damage is done.

There are fewer active volcanoes in West than in East Africa, although there are many signs of their activity in the past, such as extinct volcanoes. The Canary Islands, for example, are of volcanic origin and many volcanoes, now long extinct, are found there. The Great Cameroon Mountain is also of volcanic origin, and is now almost extinct. Small eruptions took place as recently as 1909 and 1922, and lava flowed down the mountain-side.

During the earth's early history its whole surface consisted of rocks of this kind, formed from molten material. Such rocks are known as *igneous*, or fire-formed, rocks and have been formed by the cooling of the earth's surface and by lava from volcanoes. Even to-day, although it is millions of years since the earth's surface cooled, a great proportion of the rocks are igneous. When the earth cooled gradually, crystalline rocks, such as granite, were formed. Where it cooled rapidly, such as in lava-flows from volcanoes, the rocks were more uniform in structure. The lava, after cooling, solidifies and forms various kinds of rocks which are often like cinders in appearance, and still porous owing to the bubble holes formed when the lava was cooling. At other times the lava may be compact and glassy, its form depending upon its composition and rate of cooling.

The soil formed from igneous rocks may be of many kinds, depending largely on the composition of the original rocks. Although not all igneous rocks form good soils, soils of volcanic origin are often rich, and good for agricultural purposes.

The soil of the Canary Islands, for example, although comparatively thin and stony, is so rich that when water is brought to it by irrigation, wonderful crops of bananas and other plants can be grown. Similarly in Java, Sumatra, and other parts of the East Indies the islands are of volcanic origin, and some of the richest agricultural soil in the world is found there. Some igneous rocks, however, such as quartz, decompose to form very poor soils.

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stretches on the flat portions of the valleys. The water at these places is shallow and is almost still, and drops most of the rock particles which it contains. When the water recedes to the proper river-bed, at the end of the rains, layers of small rock particles are left in large stretches of the surrounding valleys, sometimes forming vast mud flats. These broad thin layers form what is known as *alluvial* deposits. At the mouths of certain slow-flowing rivers great beds of alluvial material accumulate, so that they become closed and the water has to seek outlets to the sea. These outlets gradually become choked with alluvial deposit until the mouths of the rivers extend farther and farther out to sea. Finally the water reaches the sea through a network of waterways surrounded by great areas of this deposited material. River mouths of this kind are known as *deltas*, and the soil deposited is known as *alluvial soil*. Alluvial soil is usually rich, and in Egypt, where the mouth of the Nile is a huge delta, there are many wonderful farms in that region. Whereas the insoluble portions of the rocks are deposited in deltas, some of the soluble portion is dissolved in the river-water and finds its way into the sea and helps to increase its saltiness.

Through countless years, this depositing of alluvial material has been going on all over the earth, until thick layers have been formed. The pressure of the upper layers has often been very great. The tiny transported fragments of igneous rocks have been pressed together, sometimes cemented by clay, iron oxides, and other materials, until they have been changed once more into solid rocks. These rocks, although of practically the same composition as the igneous rocks from which they originally came, are entirely different in form and often consist of layers or *strata*, which can easily be seen when they are broken across. As they were originally laid down by the water they are called *aqueous* or water-formed rocks. When the layers or strata are easily seen the aqueous rocks are said to be *stratified*. Such rocks are also laid down by the depositing of the broken particles in deeper water during the wearing away of rocks along the coasts of seas and lakes. The raising or lowering of the land surface above or below the water due to the movements of the earth's crust also helped in the formation of aqueous rocks.

Sandstone is one of the most familiar examples of aqueous rocks. It is composed of sand which has been laid down in con-

tinual layers in water until it has become cemented and hardened into rock as a result of pressure. Similarly layers of certain types of clay when hardened form a rock known as slate, which is used in slates in some schools. When the rock formed by layers of clay is not hard enough to form slate it is often called shale.

Sometimes an igneous or an aqueous rock may be altered after its formation by either heat or pressure, or by a combination of both. Granite, for example, which is an igneous rock, may be melted again by heat, and subjected to pressure so that, after cooling and recrystallizing, its original form is quite changed. Such altered rocks are called *metamorphic* rocks, a term meaning that their original *form* has been *changed*. Some of the crystals have been pressed into rows or layers which are frequently curved and which are called *laminae*. Although the laminae of metamorphic rocks in many ways resemble the strata of aqueous rocks, the latter are generally even in texture and laid down regularly and the rock often splits quite easily along them, whereas the laminae are often curved, unequal in form, and do not split. When granite has been melted and changed into a laminated form by heat and pressure, it forms a rock known as *gneiss*, examples of which can be seen in the Krobo and Shai hills of the Gold Coast.

Metamorphic rocks may be formed from aqueous as well as from igneous rocks, if they have been heated or melted, and perhaps even subjected to pressure as well. Sandstone, for example, when heated sufficiently forms an entirely different rock in which there is no sign of the original strata. Even the sand grains themselves are no longer visible but have been melted and fused together to form a glassy-looking rock of fine texture which is known as *quartzite*. Quartzite is therefore a metamorphic rock composed of altered sandstone, being harder than sandstone and useful for road-making and for building. It is common in West Africa and was the rock used in the building of Achimota College, the stages between sandstone and quartzite being easy to see in the quarry from which the stone was taken. (See Fig. 1.)

Metamorphic rocks may be broken down in their turn by the action of water to form aqueous rocks in the way already studied.

All three kinds of rocks, igneous, aqueous, and metamorphic, gradually form soil. The processes by which they do so are

generally known as *weathering*, as the weather plays such a large part in it, whether by the action of water, heat, wind, or the oxygen or other gases in the air.

The action of water in breaking up the original rocks and forming sediments which finally harden to form aqueous rocks has already been described. This breaking up of rocks by the action of rain, rivers, lakes, or seas never ceases and is always helping to form soil.

Water, besides wearing away rocks and carrying small particles to new places, is also able to dissolve soluble portions of rocks which are carried away in solution, and redeposited later when the water evaporates. Most rocks, however, are insoluble or only slightly soluble in water. When the gas carbon dioxide is dissolved in water, it forms a weak solution of carbonic acid, which is able to dissolve certain rocks, particularly those containing lime. As carbon dioxide is produced by decaying materials in the soil, the soil-water soon dissolves it, forming carbonic acid, which gradually dissolves part of the underlying rock. The dissolved material is carried elsewhere, and when the water evaporates the substance is left as a deposit.

One of the greatest influences in the breaking up of rocks is variation in temperature. Heat, as we know, makes things expand. This continual daily expanding of rocks, and contraction as the sun declines and the air grows colder in the evening, causes the rocks to crack. When the rock is of uniform structure, such as quartz, which is composed of silica only, the effect of such expansion and contraction is not so great. In rocks such as granite, however, which consists of three minerals, quartz, felspar, and mica, each of which expands at a different rate, the expansion of the whole rock is therefore uneven and the rock cracks and breaks up far more easily. Water gets into the cracks, wearing away the rock still further. When water becomes heated, it is able to dissolve more material, particularly when it becomes imprisoned in rock crevices.

In temperate and high mountain regions rocks are sometimes shattered through the water imprisoned in their cracks freezing and expanding.

Wind also helps to break up rocks. In wind storms masses of sand and dust are blown with great force by the wind, and it is painful when the face is bombarded with such particles. In true sandstorms, such as occur in Northern Nigeria and in the Sudan, it is even worse and the small sharp-edged particles

of sand, when blown against portions of rock, break off small particles from the surface.

Sometimes the dust or sand particles are swept into drifts or deposits by the wind. This is most clearly evident in the Sahara desert, where the sand is continually moving, and the action of the wind is seen on its surface which is often covered with ripple-marks like those on water. Such wind-deposits of soil or sand are called *Aeolian* or wind-formed soils, and although they form the usual type of soil in the Sahara desert, they are seldom found in the more fertile parts of West Africa.

The oxygen of the air is continually acting on the rocks, oxidizing the outside layers which go to form soil. There is iron in most rocks, however, so that when exposed to the air the iron compounds oxidize or rust and the rock surface becomes yellow, brown, or reddish in colour, as can readily be noticed when new road or railway cuttings are made. This brownish layer or crust gradually crumbles and forms soil. Rain-water also helps to oxidize the rock surfaces beneath the soil, as it often has quite a large proportion of oxygen dissolved in it.

Another great influence in the breaking down of rocks for soil formation is plant-life. The roots of plants penetrate into the subsoil and into the small cracks in the rock below. These tiny roots give off a weak acid which helps to dissolve the rocks with which they come into contact. Rootlets of trees, after penetrating small cracks, often expand with age, until great pieces of rocks, or boulders, are frequently completely split by large roots of trees which originally penetrated small cracks as tiny rootlets. (See Fig. 1.)

After their death plants decay in the soil, forming certain substances which, when dissolved in the soil-water, have a mildly softening effect on rock surfaces.

Much can be learned about the formation of soil from rocks by visiting railway or road cuttings, or better still a neighbouring quarry or gravel pit. (Fig. 1.) At these places complete sections of the soil can be seen, and all the different stages between the underlying rock, subsoil, and soil can be studied with ease. In some places the surface or dark-coloured soil is only a foot deep or even less, and the subsoil may be 6 to 8 feet deep or more, while sometimes the subsoil consists mainly of gravel. At other times the gravel is found beneath the subsoil, and then the solid rock is usually found at no great depth beneath the gravel. Generally between the gravel and the rock itself there is a

portion consisting of rock fragments of various sizes. In this way it is easy to see that the underlying rock has gradually been broken into fragments which in their turn have become broken into smaller particles until they become small stones, pebbles, sand, or clay.

A study of such soil sections in quarries, cuttings, and elsewhere shows that many soils are derived from the igneous,

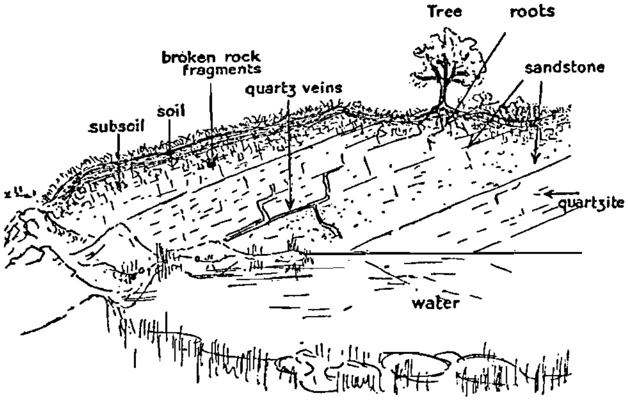


FIG. 1. Diagram of quartzite quarry, showing stages from quartzite to sandstone, broken rock particles and subsoil, surface soil.

aqueous, or metamorphic rocks immediately beneath them. Such soils are known as *residual* soils.

When the soil particles have been carried to their present position by such agencies as wind and water (and also glaciers in cooler regions), the soils are called *transported* soils.

The type of soil, therefore, depends both on the composition of the original rock and on whether the soil was formed in place or carried a long distance.

The story is, however, by no means ended, for the very agents which split up the rock to form soil continue to act on the soil they have formed, which then becomes 'weathered' still further. The chief agents in weathering are again water and heat, aided by the gases carbon dioxide and oxygen. Water charged with carbonic acid dissolves out or leaches soluble substances, many of which are valuable plant foods, which disappear in the subsoil water and may be deposited again at lower depths. The oxygen of the air helps to oxidize the soil particles further.

The result of this process of weathering is that, if two identical new soils are taken and exposed to different rainfalls and different temperatures, two very different soils will result. Similarly, in any one region of more or less uniform rainfall and temperature soils *tend* to become alike no matter what is the nature of the rocks from which they have been formed. In large countries, like Russia, the United States of America (and probably in large parts of Africa) where there are extensive regions with one type of climate, it is found that soils of that climatic zone are of a very definite type, distinct from soils from other and different climatic zones. As an example of a type of soil which is almost entirely the result of certain conditions of weathering, we may mention *laterite*, which is formed under conditions of uniformly high temperature and heavy and steady rainfall, and is, therefore, almost entirely confined to the tropics. It is common in Sierra Leone, French Guinea, and other regions of heavy rainfall in West Africa. The name laterite is derived from the Latin *later*, a brick, for it was first given to a soft Indian clay which hardened on exposure to air and was used, therefore, for making bricks and building houses. Many walls and buildings in Freetown, Sierra Leone, are built in this way from laterite bricks.

Under the action of heavy rain and high temperature much of the soluble materials which the plant needs, such as lime, potash, and magnesia, are washed away, so that laterite soil is generally poor in plant foods.

Clays are largely made up of three substances, silica, alumina, and iron oxide combined. In temperate climates, where there is much humus in the soil, weathering causes the removal of alumina and iron oxide in the drainage water by the process known as *leaching*, but under certain tropical conditions of heavy rainfall, high temperature, and little humus it is the silica which is removed. Laterite is formed in this way and therefore it is poor in silica, but rich in free alumina and iron oxide. That is why bauxite or aluminium ore, often containing a large proportion of iron oxide, is often found on hill-tops where the rainfall is heavy. In many parts of West Africa where the rainfall is not quite so heavy, the leaching of silica is not so complete, and whilst the soil may contain free alumina and iron oxide, yet it also contains these substances combined with silica. These soils are called lateritic soils.

The free oxide of iron often accumulates into pellets of

varying sizes, which generally occur as a distinct layer, a few inches down in the soil. These dark-red, brown, or orange-coloured pebbles are sometimes called 'laterite gravel' and are used for the making of 'bush' roads in many parts of West Africa. They are so rich in iron ore that they are heavy in comparison with other stones, and if they are melted in a blacksmith's furnace, crude iron can be obtained.

Sometimes the free oxide of iron occurs in large masses roughly fused together, and often wrongly called laterite. It must not be supposed that the presence of masses of iron oxide necessarily means that the soil is lateritic, for iron oxide is very often formed under exactly opposite conditions, that is, it is leached out from the surface soil and deposited again as a hard mass called *hardpan* at a lower depth in the soil.

CHAPTER II

THE COMPOSITION OF THE SOIL

ONE of the best ways of demonstrating the physical composition of the soil is to conduct the following simple experiment.

Take an old jam-jar and put a layer of ordinary garden soil about 1 inch thick at the bottom. Fill the jar with water and shake up everything together, standing the jar aside afterwards and allowing the soil to settle. Watch the particles of soil through the side of the glass as they fall. At first small stones and pebbles drop to the bottom, then gradually larger particles of sand, followed by smaller ones, generally known as silt. After a few minutes the finer silt and finally the clay begins to settle in a thin fine layer, the particles of which are so small that it is impossible to distinguish them properly with the naked eye. These fine particles of clay take so long to settle that the jar has to stand for several hours, or overnight, before another layer of still finer particles is deposited. On the following morning, the water in the upper portion of the jar is only slightly cloudy and the majority of the clay particles have fallen. Only the very smallest ones remain, and it may be several days before they finally settle. It is these tiny particles which cause the water in the upper part of the jar to remain slightly cloudy. Even after several days, when all the clay has fallen, this water still remains very slightly cloudy. This is mainly caused by *colloidal* substances, which are found in clay, and which will be studied in detail later.

This simple experiment, which can easily be conducted at home, or in the school-room, shows the main substances found in soil.

It is composed, therefore, of a large number of particles of different sizes, which fall through water at different rates. The very large particles are either stones or gravel, followed by coarse and fine sand, silt and fine silt, whilst the very small particles which settle only after many hours, or not at all, are called clay. All particles with a diameter of over two millimetres are classed as gravel, 0·2 mm. as coarse sand, 0·02 mm. as fine sand, 0·002 mm. as silt, whilst the term clay embraces all soil particles with a diameter of less than 0·002 mm.

Now all soils contain these various soil *fractions*, as they are called, in different proportions, and it is from the fraction which

is present in the greatest proportion that the soil takes its name. There are gravelly, sandy, silt, and clay soils. Where clay is mixed in fairly even proportions with particles of bigger size, the soil is called a *loam,* and is distinguished, where necessary, by prefixing the name of the biggest fraction, for instance coarse sandy loam, silt loam, or clay loam.

In general, soils in which sand predominates are known as *light* soils and those in which clay predominates are known as *heavy* soils. Most farm soils are either loam, sandy loam, or clay loam. Very few soils used for agricultural purposes are either pure sand or pure clay. Of the various loam soils ordinary loam is best for most crops. Sandy loams suit certain crops such as ground-nuts, and clay loams such crops as sugar-cane.

Gravel is chiefly composed of small fragments of rock, generally rounded and pebbly in appearance. Gravelly soils are common in various parts of West Africa. Most of the smaller roads are surfaced with the rounded red or yellowish gravel often found near the surface, and usually called *laterite gravel.* Each stone is comparatively heavy and contains a good deal of iron ore. It is hard and not easily broken and dissolves very gradually in soil-water and can therefore be used only very slowly by plants. Water drains quickly through gravel, and in most places where there is gravelly soil, as on steep hill-sides, plants do not thrive. Gravelly soils, therefore, are not well-suited for agriculture.

Sand consists of gritty particles which can easily be felt by rubbing them between the fingers. In fact this is one of the ways in which we find out quickly whether any given soil contains much sand.

To understand exactly what sand is, spread some out on a clean piece of white paper and examine it very carefully. A small hand-lens, if available, shows the individual particles clearly. The particles are of many different colours, black, red, brown, orange, greenish, yellow, whilst some are transparent. Most of them are either colourless or pale yellow. Try to break the particles with a finger-nail, a pencil-point, or a pin. The particles can rarely be broken, even by using metal objects such as pins. Sand is composed, therefore, of tiny fragments of hard rock. The edges of the sand particles are not all the same shape or size, and may be sharp, slightly rounded, or quite worn off. Usually they are slightly rounded, owing to the wearing of one sand particle against the other by the action of water. Most

sand consists of small fragments of a rock known as *quartz*, an igneous rock, and one of the commonest minerals on the earth's surface. It is found in the pure state, or else in an altered state known as *quartzite*. It is also one of the main constituents of *granite*. When granite is broken up, quartz particles go to form sand. The aqueous rock known as sandstone is formed by successive layers of sand laid down by water and finally hardened into a rock. When sandstone is broken up, therefore, sand is the result. Quartz is practically insoluble in water so that plants can make little use of it. Sandy soil, therefore, contains very little plant food. Water drains quickly through sand, as large spaces are left between the particles, and each particle is hard and insoluble and has no power of absorbing water. It is, therefore, a dry and thirsty soil for plants. Moreover, when the hot sun shines upon sand, it quickly becomes heated, and travellers walking over it in bare feet in the middle of the day realize how very hot it can become. Plants living in such dry soil, warmed every day to a high temperature, and containing practically no plant food, tend to die of drought, so that only the hardiest and thickest leaved ones can survive. Sandy soil, therefore, is a poor one for agricultural purposes.

Dry clay powdered and spread thinly on a piece of white paper looks quite different from sand. The particles are much smaller, and often cannot be seen, even under a magnifying glass. They hang together in groups and the slightest pressure breaks them into still smaller groups, until it seems impossible to separate a single grain of clay from its neighbour. These grains, which are microscopic in size, are of various shapes and very soft in texture. Because they are so minute they remain much closer together than particles of sand. When clay is rubbed between the fingers it does not feel gritty like sand, and the particles slide over each other smoothly. If a little water is added to the dry powdered clay and it is again felt with the fingers, it seems distinctly sticky. This is due to the presence of *colloidal substances*.

While we know little about the composition of colloids we are well acquainted with their properties. Many everyday substances are colloids; clay, glue, gum, and white of egg are common examples. The word 'colloid' is derived from the Greek and actually means 'like glue'. These colloidal substances are able to absorb water. This is proved by the way in which dry powdered clay increases in weight on exposure to

damp atmosphere, or the gum on the flap of an envelope or back of a stamp becomes sticky in the ordinary humid atmosphere of many parts of West Africa. When larger quantities of water are added to the colloids in clay, for example, not only is slight heat given off but the clay becomes sticky and expands (see Sir E. J. Russell's *Lessons on Soil*, pp. 11 and 12). The colloids in clay are also able to absorb other substances, such as dyes or plant foods in the soil. Clay is such a dominating substance that it can impart its properties to the surrounding soil particles of silt or sand. The harder mineral particles of soil become coated with a jelly-like layer of colloids, which can absorb and hold water and in which the soil bacteria live.

The sticky nature of the colloids in clay make clay soil difficult to work. It sticks to the feet and to the hoe or other farm tool and we say that it is *stiff* or *heavy*. Although this is due to the mineral colloids present, the organic colloids of humus have the opposite effect and help to counteract the ill effects of the mineral colloids in clay. Whereas sandy soil is porous and permits water to pass through it, clay soil only allows water to pass through it with great difficulty. This is because the clay particles are much smaller than those of sand, and are closer together so that water cannot pass through. Moreover, the colloids are able to absorb water, whereas sand particles are impervious. When wet the particles expand so that it is almost impossible for air to pass through moist clay. Although colloids are able to absorb water like a sponge, they cannot give it up so easily. For this reason a clay soil can hold water for a long time and gives it up only slowly. Therefore farm crops on clay soils remain green much longer in dry weather than crops on lighter soils. While this is an advantage at such times, the presence of too much clay in the soil makes it stiff and difficult to work. Before clay soils can become 'lighter' certain changes must be brought about in the colloids. One of the chief ways in which the amount of colloids in the soil is reduced is by heat. Heat changes the composition and properties of colloids, and we know that when an egg is boiled in water the white portion, which is composed of colloids, solidifies. When the egg cools afterwards it does not change its form and the hard white portion will never return to its former semi-liquid state.

This principle applies to the making of earthenware pots. Clay soil is used, with a small percentage of sand in it to 'bind'

the clay and to prevent the pot from cracking when dried. When the moist clay is shaped, it is the colloids which hold the pot together and prevent it from breaking. When the pot is fired in the oven a complete change takes place in the composition of the colloids. The finished pot is kept together because the particles of clay are so numerous and small and are partly cemented by the colloids which still remain. If the pot is dropped, it at once breaks into pieces and cannot be properly mended again. If the broken pot is pounded in a mortar, and water is added to the dry powder, and an attempt is made to reshape the pot, it will be impossible to do so, as the clay has been entirely altered by the heat. In other words, most of the colloids have been completely changed. Similarly in the soil, the clay on the surface is not so sticky as the clay beneath the surface, because the heat of the sun helps to break up the colloids. That is why it is good to turn over clay soil as much as possible so that the sun's heat may reach all parts of it and break it up gradually. The change is a very slow one, and can hardly be noticed, but it is taking place all the time in the soil. In England farmers sometimes burn quantities of clay soil in the fields and spread it over the field again. Such soil is consequently much less sticky, as the heat has destroyed some of the colloids. Clay, unlike sand, is rich in plant food, but as long as this food is in the colloid form it is insoluble in water and therefore plants cannot use it. Heat is needed to change these colloids into compounds which are soluble in water so that the plants can use the food contained in them.

A second way in which colloids are changed is by the action of lime. (For demonstration experiments see Sir E. J. Russell's *Lessons on Soil*, chapter iii: 'What Lime does to Clay'.) In Europe and America farmers spread quicklime on the land and the clay releases more of its food and gradually becomes lighter and more friable. Quicklime in West Africa, however, can only be bought in stores and is expensive, as little limestone or chalk is found in the country. Sea shells are one of the main sources of lime in this part of the world, and they should be ground up before being applied to the soil. Even so they act more slowly than quicklime.

In some districts in West Africa, such as parts of Ewe and Ga country, on the Gold Coast, shells from the seashore are specially heated in iron barrels, pounded into small pieces, and applied to the soil. This home-made quicklime is easy to make,

provided that firewood, such as mangrove wood, is plentiful. In the old days on the Gold Coast, lime for mortar used in building the coastal castles was made in this way. Another more common but inferior source of lime in West Africa is the ashes from wood fires.

The fourth material commonly found in the soil is the organic matter resulting from the decomposition of living organisms. This consists mainly of decaying plant material such as the rotting stumps of trees, bark, dead twigs, leaves, and husks of fruits. When a plant dies it gradually decomposes and forms soluble plant food which is used by new plants in their growth. The roots and rootlets underneath the soil gradually decompose also and add to the decaying organic material usually known as *humus*, although it is only part of these decaying plants which really forms humus. Soils rich in humus are called *humous soils* and are usually rich in plant food. The presence of humus in the soil often darkens the surface soil and generally makes it darker than the subsoil.

Humus, being a colloidal substance, also acts as a kind of sponge in the soil, holding the water so that the plants can use it later in dry weather. Humus in a sandy soil prevents it from losing its water too quickly and also keeps it cooler and more suited for plant growth. Humus also contains a certain amount of colloids which make the soil less 'stiff'. These colloids, unlike those in clay, decompose rapidly and finally release their plant food in a soluble form.

It is sometimes possible to prove the presence of humus in the soil by burning it. The sand and clay will not burn, whereas the humus will. When humus is burnt a fine white powder is left, just as when wood, leaves, or sticks are burned, wood-ashes remain. These wood-ashes have been present in humus all the time, although in a combined form and not in the state of ash.

Forest soils in West Africa are generally rich in humus, owing to the large amount of plant material constantly decaying in the soil. In the dry grassy plains, however, most soils are deficient in humus. Every year huge fires sweep through this type of country, burning the dried grass and dead leaves which would otherwise decay in the soil and form plant food. In all regions where bush fires occur, the soil is becoming poorer in humus every year. This means that fewer plants can thrive, less humus is therefore formed, until these areas are becoming dry and barren wastes by slow and imperceptible degrees.

Many older men in West Africa can remember how much more fertile such regions were in the days of their boyhood than now, largely owing to the disastrous bush fires and the consequent gradual destruction of most of the valuable humus.

Another substance present in many soils is *lime*. It may exist in the form of chalk, limestone, or marble, all of which are of the same composition, but of different form. In the south of England and in many parts of the world the soil is rich in lime, but in West Africa where these rocks are only rarely found, soils are poor in lime. There is lime in wood-ashes and in humus. Most soils in West Africa would be improved by the addition of lime, either in the form of quicklime, powdered shells, or wood-ashes.

CHAPTER III

PLANT FOOD IN THE SOIL

PLANTS require food to build up their bodies, forming roots, stems, leaves, flowers, and finally seeds by which they mainly reproduce themselves. This food they obtain from the air and from the soil. The manner in which plants manufacture starch in their green leaves from the carbon dioxide in the air, with the help of chlorophyll and in the presence of water, can be studied in elementary botany. Plants are mostly composed of water, and when dried lose weight. The dry fibrous portions remaining consist mainly of substances known as cellulose, starch, and sugar. Cellulose and sugar are of much the same chemical composition as starch from which they are derived. Starch was in its turn formed from water from the soil, and carbon from the carbon dioxide of the air. If these dried fibrous remains of a plant are first weighed and then burnt they give off smoke and form a black smouldering mass called carbon. When heated further whitish coloured ashes are finally formed, much smaller in volume and weight than the dried plant before burning. Carbon changes to carbon dioxide in the process of burning and so returns to the air from which it came, whereas the ashes cannot be burned further (unless heated in an electric furnace). These ashes represent the mineral portion or 'mineral ash' of the plant, and as they did not come from the air, it is evident that they originally came from the soil. In botany we learn that the plant takes its food from the soil, only in the soluble form, through its root-hairs. Therefore these ashes represent the original salts taken up in solution by the plant, and are therefore soluble, as can readily be seen by the way in which white wood-ashes soon dissolve in the soil in rainy weather. When these ashes or 'lye' are used in the making of home-made soap they soon dissolve in the water added to them.

These mineral salts or ash left when the plant is burned are whitish in colour and consist of a mixture of soluble 'salts'. These salts or chemical compounds are derived from only about a dozen elements, namely potassium, sodium, oxygen, phosphorus, chlorine, calcium, iron, magnesium, aluminium, sulphur, silica, iodine, and one or two others. Most of them are, of course, found in the form of compounds with other elements, the oxygen, for example, being found chiefly in the form of

oxides, sulphates, and other compounds. Of these compounds, three groups are regarded as especially valuable in agriculture, and, as they occur later in the book, they will be described briefly here.

These important plant foods are generally known under the names of (1) 'nitrogen' or 'nitrogen compounds' (chiefly in the form of nitrates), (2) potash salts (compounds of potassium), and (3) phosphate salts (compounds of phosphorus with oxygen and often with calcium or other elements). Lime, a compound of calcium with oxygen, and often with carbon as well, when the compound is chalk or limestone, although not so valuable a plant food from an agricultural point of view as the first three, is generally classed with them as of great importance.

The remaining essential elements, generally found in the form of compounds, are, of course, necessary to the growth of plants, and it has been proved that plants do not do so well if any one of them is missing. For example, plants have been grown experimentally without iron salts and they were then unable to form proper green chlorophyll in their leaves. As soon as iron salts were added, even in small quantities, chlorophyll was formed normally. There is fortunately plenty of iron compounds in soils as well as these other substances. It has been found, however, that the nitrogen compounds, potash and phosphates, often become so reduced, either by wasteful methods of agriculture, or in the case of nitrogen compounds particularly and potash as well, by loss in drainage water, that some method of replacing them has to be devised if the crop yields are not to fall too low. That is why these three groups of plant foods play so large a part in scientific agriculture. Some of them, notably salts of potash and phosphates, are found to some extent in the mineral or 'inorganic' form in Nature. Nitrates, however, are seldom found in the pure form in rocks but are chiefly derived from what is known as 'organic' sources, that is from the decay of organisms, whether plant or animal. Nitrogen compounds, as well as potash, phosphates, and other salts, are found in the decay of organisms in the soil. In the West African forests where vegetation is often luxuriant, and animal life correspondingly meagre, it is the decay of plant life that mainly adds this valuable organic matter or 'humus' to the soil.

We have seen how a plant particularly needs such foods as nitrogen, phosphates, potash, and lime to build up its tissues.

These substances the plant uses in its growth and portions are stored in its seeds, or, as in cassava and yams, in the roots and underground stems, for the use of the next generation. In the process of the work of building up new tissues and of manufacturing reserve food for future generations, waste products are got rid of by plants. Of these products carbon dioxide and water are the main ones, although other waste substances, such as tannin, for example, are excreted in the old leaves which all plants discard from time to time. The bark of trees and old wood are also full of waste matter, so that when old trees decay in the forest they are adding food to the soil.

Just as growing plants take the simple chemical substances which are found in solution in soil water to build up their complex structure, so, when they die and decay, these complex materials gradually decompose and form simpler substances. One of these, carbon dioxide, is given off into the air, while others finally dissolve in the soil-water and are absorbed once more by young plants. Other organisms, such as fungi and bacteria, also help to break down the decaying plant materials, and gradually form more soluble substances. Their own bodies also finally decay and help to form plant food in the soil.

Much organic material is destroyed in tropical soils by the action of termites or 'white ants' which feed upon bark, wood, dried grass, and other substances. Their earthen nests vary greatly in size and shape, some of them being over 6 feet high and composed mainly of subsoil cemented together with juices from the insects' mouths. The soil formed from these earthen nests and from those of numerous types of true ants, are generally unsuitable for agriculture, especially when freshly made, although some old decayed nests appear to yield good soil, probably owing to the organic matter stored in them. From analyses made at Rothamsted of old and new 'ant-hill' soil from Sierra Leone, it was found that the new heap, in comparison with the old, had a lower content of nitrogen, potash, and phosphates than the old heap, and also a very small bacterial population, another sign of its poverty in plant food. There was also a striking difference in the physical condition of the two soils, that from the new heap being sticky and that from the old heap friable in comparison, and therefore more suitable for farming purposes.

So the cycle of life goes on, each generation of plants living on the decaying remains of their ancestors as well as on the

remains of dead animals. Therefore decaying plants are rich in plant food and should not be destroyed, unless it is unavoidable, as when diseased plants must be burned to prevent the spread of the diseases or insect pests which they contain. In thick forests where leaves are continually falling and decaying and dead trunks and branches of trees rot rapidly, the soil is much richer in humus and therefore in plant food than sandy soil near the seashore or on the grassy plains. Forest soil is generally blacker and more spongy, and all farmers know that crops grow best during the first year or so after clearing virgin forest because the soil is so rich in humus.

On the grassy plains, on the other hand, the bush fires destroy, every year, quantities of vegetation which would otherwise have formed rich stores of humus, and the valuable organic matter goes into the air as smoke and gases instead of returning to the soil.

Not only does humus add plant food in the form of chemical compounds to the soil, but it also improves the physical composition or texture of the soil. When humus is added to sandy soils they can hold more water because the humus acts as a sponge and prevents too rapid loss of water. Moreover, humus helps to keep the temperature of sandy soils more uniform. Clay soil also is improved when humus is added to it. The humus opens up the clay and helps the air to act upon the clay particles, which are gradually converted into soluble plant food.

In most parts of West Africa a farmer, after clearing his farm, allows the cleared 'bush' to dry. It is then put in heaps and burned before the crops are planted. In the West African forest where plants grow rapidly, most of the bush consists of trees, shrubs, and climbers with woody stems. These it is practically impossible to dig into the soil and they take many months to decay, even if dug in. It is therefore easier to burn them, but every effort should be made to prevent the young soft twigs and the leaves from being burnt. They should either be cut off with a cutlass or left until most of the dead leaves have fallen to the ground. Under no conditions should leaves be raked together in heaps and burned when this can be avoided.

If possible leaves and tender stems should be dug into the soil with a hoe, and decay then takes place more rapidly. Much valuable material and time is lost if the plants are allowed to dry on the surface.

In districts where grass predominates, it should be buried as

soon as it is dug up by the roots. This means a certain amount of trouble at first, but soon becomes a habit. The grass is dug out by the roots by one or two sweeps of the hoe, then held in the left hand while, with the hoe in the right hand, the hole from which the grass was dug is deepened with the hoe. The clod of grass is then put into the hole with the roots sticking upwards and covered with the remainder of the soil from the hole. Another method is to dig over the soil continually so that a small trench 4 or 6 inches deep is left. Into this are put the fragments of grass or weeds folded up and a layer of soil is pulled on top of them, the hollow or small trench left being filled with the next lot of grass and weeds which are then covered over in their turn. This method prevents the burning of any plant material except the woody roots and stems. After practice it becomes automatic and little more trouble than the old system. It is well worth while, as the soil is more thoroughly dug and turned over. Also all the weeds and grass are covered, often while still green, and turn into plant food instead of being put into small heaps and burned on the surface as so often happens. Sometimes, of course, they are spread on the surface of the soil to form a 'leaf mulch', which keeps the soil cooler and moister in dry weather and helps to prevent soil wash during the rains. The best way in which these new methods can be introduced into African farming is through school gardens or through experiments by enlightened farmers on their own farms as demonstrations to their neighbours. If all teachers believed in the value of it and got their children into the habit of burying weeds on their plots, a great service to agriculture would be done, and improved methods could be instilled into the boys and girls, once their initial prejudice had been overcome.

Soil Bacteria

Plants which are buried or are allowed to die in the soil soon decay. During the dry weather practically no decay seems to take place, but as soon as the soil becomes moist decay sets in much more rapidly. This decay is mainly caused by tiny organisms called *bacteria* which can only be seen under a powerful microscope. These bacteria are present everywhere, in the air and in the soil. Every one is aware that organic material such as foodstuffs like meat or fish quickly decay. Tinned meats and fish, however, can last in their tins for months and even years without decaying, and it is interesting to see why this is

so. Before being tinned these foods were boiled or heated to such a temperature that all the harmful decay-causing bacteria were killed, as bacteria are destroyed by heat. At this stage the hot food-materials were put into tins which were sealed up at once to prevent the entry of air and the spores of disease and bacteria which air contains. While inside the air-tight tin the food is free from bacterial attack, or in other words, it is *sterile*. Once the tin is opened bacteria begin to attack the food, and if dirt or soil is allowed to enter the tin, the decay takes place quicker than ever. Therefore tinned foods should be turned out into clean dishes and eaten with as little delay as possible.

This decay of organic material is taking place continually in the soil, and the soil bacteria feed upon the complex organic compounds, breaking them down into simpler substances. These bacteria need certain conditions before they can carry on their work, and these conditions are (1) warmth, (2) air, (3) moisture, and (4) lime.

In cold countries soil bacteria do most of their work in the warmer parts of the year and practically cease their activity when the cold winter comes. In the tropics where the temperature is higher, the soil bacteria are generally more active and the decay of humus in the soil is usually much more rapid. Most bacteria must have air, however, before they can live and work properly, and they use oxygen and give off carbon dioxide. Therefore they are more active in breaking down the humus in lighter sandy soils than in heavy clay soils, because there is more air or 'pore space' in light soils. In very stiff clays, and in marshy waterlogged soils, helpful bacteria very often cannot work properly and humus decays slowly. Therefore these soils are often unhealthy and unsuitable for farm crops unless drained to allow the entry of air. There are, however, other classes of bacteria which can live and work without oxygen, but as they are of less value to agriculture than those requiring oxygen, they will not be dealt with here.

The third condition required is moisture. We have already seen how decay almost ceases in the dry season. Also during the rainy season decay is much more rapid in the regions of higher rainfall in the thick forest country than in open grassy country, even though the temperature of the latter is often slightly higher in the day time (and lower at night). This is because there is more moisture both in the air and in the soil in forest country and, provided that there is plenty of air in the

soil, the soil bacteria are probably more active and the decay of plant material more rapid in the soils of tropical forests than in any other part of the world. From experiments conducted in Nigeria it has been proved that beans dug into the soil as green manure during the rainy season decay rapidly and that the supply of valuable soluble plant food is formed so quickly that it lasts for only a comparatively few days.

The fourth condition necessary for soil bacteria is lime. Lime is an alkali and helps to neutralize the acids in the soil. If lime is deficient, as it is in many parts of West Africa, the soils are acid and therefore proper and healthy decay of plants cannot take place. If lime is present and soil conditions are more nearly neutral and 'sweet', plant decay takes place more rapidly as the soil bacteria thrive under such conditions. As plants decay they tend to form acids known as organic acids in the soil; the presence of lime helps to neutralize these acids. The bacteria then gradually break down the organic material in the soil into simpler compounds, until soluble substances known as salts are formed. During the process of decay the bacteria, which are living organisms, breathe in oxygen and exhale carbon dioxide, giving off heat, consume food and excrete waste products which are simpler in composition. Other bacteria live on the waste materials given off by higher forms of bacteria, until the process is complete and only 'salts' are left. Therefore the process of decay caused by bacteria in the humus in the soil is somewhat the same as if the humus had been burned by fire with only the ashes remaining, except that the process is much more gradual. Many of the complex materials of plants are broken down by bacteria through the stage of ammonia to soluble salts known as *nitrates*. This process is known therefore as *nitrification* and is taking place normally in all healthy soils.

The roots of leguminous plants possess swellings known as 'nodules' in which nitrogen-fixing bacteria live. These useful soil bacteria are described more fully in the chapter on 'Crop Rotation and Green Manuring'.

Besides the normal bacteria causing decay in the soil, resulting in the production of useful and soluble plant food, there are other soil bacteria working which are not useful to the plant. In sour soils and in waterlogged soils, for instance, the bacteria which exist under such conditions act in a different way upon the plant food present, and sometimes change soluble plant food such as nitrates into less soluble and useful substances, and

even into free nitrogen which escapes into the air as a gas. This reverse process, which is known as *denitrification*, is harmful to the farmer and should be prevented by making the soil conditions normal and healthy by drainage, liming, adding humus, or by combination of these processes.

Other organisms in the soil cause disease in plants and animals. The damage done by those known as fungi is dealt with in the chapter on 'Plant Diseases'. Amongst harmful bacteria present in the soil, it is only necessary to mention those causing lockjaw or tetanus, a disease which can enter through open cuts in the finger coming into contact with soil, and anthrax, a deadly disease causing the death of farm animals and even of man.

Under conditions of heavy rainfall and high temperature, such as occur in the West African forest region, therefore, not only is vegetation thick and rapid in growth, but it also decays quickly, owing to the abundant bacterial life in the soil. Under normal conditions, as we have seen, this humus decomposes rapidly, forming soluble salts which are soon used up by new plant growth and this, *if not disturbed by fire or by man*, becomes more luxuriant every year. This tendency of plant life in West Africa to increase in luxuriance means that every year increasing amounts of humus in the form of dead leaves and other decaying plant material are being added to the soil, so that the longer man leaves the forest untouched, the richer does its soil become. Therefore the soil of the so-called 'virgin' forest is generally much richer than that of the secondary growth, sometimes called 'secondary forest', which springs up on old deserted farms. In more open grassy country, however, where it is almost impossible to prevent bush fires in the dry season, much humus is destroyed by fire and young trees are burned and older trees injured, so that the tendency is for such vegetation to become *less* luxuriant and therefore for the amount of humus in the soil to decrease every year. When farmers add humus to such soils, excellent results are generally obtained.

As plant food tends to increase naturally in closed forest country by the rapid growth of plants, it is obviously most wasteful to leave the soil bare at any time, especially in the rainy season. If large areas of forest soils are left bare, or only partly covered with crop during the rainy season, the heavy rain quickly washes out or 'leaches' the soluble plant food, particularly the valuable nitrogen compounds. It is therefore essential

to keep the soil continually covered either by mixed crops, closely interplanted, as is the usual African custom, by green manures or cover crops, by secondary growth, or best of all, by proper forest, if one does not wish the soluble plant food to be washed out, but rather the supply of plant food to be constantly maintained and increased.

CHAPTER IV

SHIFTING CULTIVATION

As we have seen, when forest country is left undisturbed in West Africa, soil fertility is maintained by the continual addition of decaying plant material or humus. After man in West Africa ceased to live on wild fruits and roots, or even merely to hunt, he settled down to primitive agriculture and the growing of crops, and cleared areas of vegetation to make his farms. He chose the richest parts, generally in valleys or where there were 'pockets' of soil, and after exhausting them, he moved elsewhere, allowing his farms to go back to Nature, the great restorer. This method of farming, now known as 'shifting cultivation', was once more universal than now and was practised by most races of man until they were forced by wars, pressure of population, starvation, and the difficult conditions of modern civilization to adopt modified methods of agriculture. These methods, which are often called 'rotation of crops', will be dealt with later. We will now consider methods of shifting cultivation in West Africa, and why it is still so widely used amongst West African farmers.

Shifting cultivation as a system of agriculture has developed quite empirically amongst all West African tribes. Under this system certain areas are cultivated or farmed for a time, and then the farms are shifted to new areas, preferably of untouched or virgin forest, which are deserted in due course for new farms. The extent of a whole farm can often be seen at a glance in Europe, but in West Africa this is practically impossible. Each farmer generally has two or more distinct farms, consisting of areas of cleared bush covered with crops. These farms, which average about 3 acres per year per farmer, may be at various distances apart, sometimes a mile or even more. After a year or two the old farms cannot be seen, and the farmer will have two or more farms elsewhere, often widely separated in entirely new parts of the forest. Though strange to the European, this has been the practice for generations, not only in West Africa but in many parts of the continent and in other parts of the tropics where similar conditions prevail. It is in use in the forest country in the hills of Upper Burma, where the forest is thick and the population sparse, and in many parts of the tropics which are inhabited by the original non-European

populations, and where there is plenty of land to spare and a comparatively small population. In countries like India and China, where the population is very dense, different methods of agriculture more nearly allied to those of thickly populated European countries are used. This practice of shifting cultivation in West Africa can be traced, therefore, to two main causes. The first reason is practically unlimited land and a relatively small population. In the Gold Coast, for example, where the area is roughly the same as that of Great Britain, the population is only about 3,000,000, as compared with practically 40,000,000 in Great Britain. This applies also to many parts of Africa including the West Coast, but in regions of dense population the system of shifting cultivation is sometimes considerably modified.

The second main reason for shifting cultivation in West Africa is the nature of the country and its vegetation. In the closed forest, where most plants are trees or shrubs with woody stems, it is impossible to dig them into the soil, especially with the primitive hoes which most farmers have. The bush is cut down with a cutlass and when dry it is burned. Its ashes are generally the only manure added to the soil. During the first year the soil is naturally rich owing to the numbers of leaves which have decayed in it for years, and also, but to a less extent, to the wood ashes. In the second year the land is not so rich, so that sometimes at the end of the second, third, or fourth year the farmer decides to desert his farm. This is chiefly because he notices that the soil is rapidly becoming poorer. He is removing plant food in the form of products of his crops without adding any manure or plant food in return, and much plant food is washed out of the soil by rain. Animal manure is practically unobtainable, and to dig in the mass of green stems and leaves is, as we have seen, very difficult with the farmer's present tools. Therefore he finds it easier in the long run to undertake the difficult work of clearing new areas of forest, as he knows that he gets his best crops from virgin soil. Generally he has no difficulty in getting new land from his chief, so it is small wonder that he practises shifting cultivation.

When the cleared areas have been farmed and the soil is partly exhausted he simply allows them to return to bush. Once covered with bush and weeds, they gradually regain part of the fertility which they have lost. The falling leaves enrich the surface soil which grows gradually richer every year.

This method of 'leaving it to Nature' is naturally simpler and cheaper than sowing the seed of leguminous crops and later digging the plants into the soil. In old times, moreover, it was the method adopted in European agriculture and was called the 'fallow'.[1] In parts of England farmers used sometimes to allow a field to lie in fallow for a season, that is, they allowed weeds to grow on it. This practice was part of what used to be called the 'three-course rotation'. Its great advantage was that it gave the land a rest, and afterwards the weeds were ploughed in, thereby enriching the soil. The West African method is like a fallow, but land is generally allowed to lie in fallow for many more than one or two years. This gives the land a rest from cropping, and also adds plant food to it, although not so much as could be added if the 'fallow' could be ploughed or buried in the soil at the end. That is, of course, the cheapest and easiest way for the West African farmer.

Another advantage is that the constant moving of farms prevents the rapid spread of disease and insects which attack farm crops. In the European and American system of farming, especially in places like the United States, where practically only corn and cotton are grown in 'belts' over large areas, the damage done by one disease or insect pest may be enormous. It spreads from farm to farm at an alarming rate until sometimes the growing of certain crops in certain parts of the world is practically given up, as for instance Arabian coffee on Ceylon plantations. Where the farms are small and scattered and often separated by areas of thick forest, as in many parts of West Africa, there is not the same danger. Also, on his much smaller farms the African generally practises mixed cropping, that is growing two or more crops mixed together on the same piece of land. At the end of two or three years the farm is abandoned, and any pests or diseases present suddenly find themselves without their 'host' plants and are therefore often checked. In the new piece of bush that the farmer clears there are generally few diseases or injurious insects, and many of them are destroyed when he burns the rubbish before planting his crops.

Many Europeans believe that shifting cultivation is an aimless method of clearing new bush every two or three years, and

[1] Not to be confused with a 'bare fallow' which is a more modern practice in England in which the soil is kept free of all plants for a season. The bare fallow is generally adopted to get rid of weeds, and of certain diseases and pests.

continuing this wasteful practice more or less *ad infinitum*. If one judged only by appearances it would seem to be so, but actually it is generally more systematic than it appears to be on the surface. One farmer may have one or more pieces of land allowed for his use by the chief, on which he practises the system we have already studied. After a time, generally varying from six to twelve years, he returns to his original farm or farms and clears the 'bush' which has grown up on them. Shifting cultivation of this kind, therefore, is really a modified form of crop rotation, being a long rotation of anything up to fifteen years' duration consisting of two to four years for the growth of crops, usually followed by a long fallow of six to twelve years.

Under modern conditions, however, there are many exceptions to this rule. When the population in a district increases or decreases, the farmer is naturally inclined to shorten or lengthen his long 'rotation'. Where his series of farms have been in use for a long time and when there is new and untouched forest near by, he generally gets permission to clear and farm part of it. When the population in a district increases and there is virgin forest available, the tendency is for part of it to be cut down and brought into cultivation, as West African farmers naturally prefer to farm it in preference to secondary forest, as the soil is so much richer. Also where the population is variable from year to year, as it is in many places now, owing to the increasing movement of Africans in all directions, the system of moving from plot to plot is much more irregular. New people coming into the district may clear old farms and use them for a time, abandoning them again when they leave the district. The whole system of shifting cultivation nowadays is continually being modified by shifting populations and by the opening up of the country to European influences. Consequently the system of shifting cultivation as practised in more populous districts is poorer and more destructive than that in use before the country was opened up, and which was outlined earlier in this chapter.

Occasionally shifting cultivation gives better results than suggested methods of crop rotation, even when green manuring is practised. This occurred on a Southern Nigerian Experimental Station where, however, the soil was acid and poor. This is, of course, only one case where shifting cultivation has been proved by actual experiment to give better results, and it is impossible and unwise to generalize from one result. Other

unknown causes may have been the reason for this result, and such results may not have been obtained with other crops, or in other districts, or in a different season. In fact there are many factors which may have given entirely different results, and it will be impossible to judge finally until we have the results of years of experiment, with all kinds of crops, in various districts, and in all types of seasons, and until reliable averages can be made.

The disadvantages of shifting cultivation are much more obvious, and therefore more often quoted.

The main disadvantage is that it is a very wasteful method. Four or five times as much land is required to raise the same amount of crops as could be grown under a rotation system. Roughly four-fifths of this is generally covered with useless bush, known as 'secondary forest', the old deserted farms being soon covered with trees and shrubs which, because of their speedy growth, are soft-wooded and practically useless for timber or domestic purposes. If rotation were practised and the same land cropped continually, the remaining four-fifths could be allowed to go back gradually to permanent forest. Then the slow-growing, hard-wooded timber trees would ultimately hold sway again, or else these large areas could be specially planted with quick-growing timber or firewood trees. Under shifting cultivation, pieces of rich virgin forest are cleared and hard-wooded trees, which have taken many years to grow, are cut down and destroyed. Any method of farming which means cutting down forest, especially on hill-sides where the soil is so easily washed away, is helping to drain away the natural wealth of the country. Moreover, some authorities declare that the destruction of forests reduces the rainfall of a country.

One great disadvantage of shifting cultivation is the burning of all the cleared 'bush' which has been allowed to dry. As we have seen, this means the yearly destruction of great quantities of valuable humus. Under a system of crop rotation this burning can be avoided, or greatly reduced.

Where wholesale planting of economic crops such as cacao on the Gold Coast occurs, the area of bush left for the growth of food crops is greatly reduced, and the land shortage is often also aggravated by an increase of population and new areas set aside by Government as forest reserves. This means either the clearing of virgin bush for the purpose, a decrease in the number of

years before an old farm is cleared again, or a combination of both. The rapid rise of towns along the railways or main roads where produce is bought and sold in increasing quantities, means greater land shortage near such towns. The food problem is often great, and prices rise rapidly. Gradually communities of farmers arise and devote themselves chiefly to the growth of foodstuffs for the towns. As these increase in number, the land shortage will become more acute, and existing land will be cropped oftener. This cannot continue indefinitely, however, and sooner or later the African farmers will be driven to practise crop rotation and manuring.

Shifting cultivation has therefore been abandoned in many countries owing to the same causes which are making it break down in West Africa and will continue to do so. In parts of the Niger province, the population is so dense that most of the original forest has been destroyed and the land is longer under cultivation than resting under 'bush fallow'. The same conditions apply in parts of Mende country and other parts of West Africa. The soil is also becoming rapidly impoverished, and before long the people will be driven to adopt some more advanced and less wasteful method. Some farmers attempt to manure the soil with animal excreta and sweepings from their compounds, but this is quite inadequate to the needs. Therefore the main problem preventing the abandoning of shifting cultivation is a problem of *manure*. These different methods of conserving or increasing soil fertility by crop rotation, green manuring, farmyard and other manures will be dealt with in the succeeding chapters.

CHAPTER V

CROP ROTATION AND GREEN MANURING

Crop rotation is only a partial solution of the land hunger and soil exhaustion following on continual shifting cultivation. Although the rotating of crops on a piece of land is generally considered better for the soil than the continual growing of one crop only, this was only of secondary consideration when farmers in other countries adopted crop rotation. The rotations adopted in various districts were decided by convenience and local conditions of soils, crops, and markets. Moreover, the need for growing food for domestic animals in the rotation became generally felt. Therefore the types of rotation adopted in any district in West Africa in the future will be largely decided by convenience and by the economic value of the crops grown.

Rotation of crops means the growing of crops continually on the same piece of land in such a way that they follow in a proper rotation or cycle. There are many different kinds of rotation, depending on the number of crops grown. Where two or three crops follow each other in the same order, time after time, it is known as two-course or three-course rotation. Similarly it is possible to have four-, five-, or six-course rotations, or even more, but three- or four-course rotations are generally most popular. Such rotations have been in use in European farming for generations, and certain rotations have become typical of certain districts. There are several kinds of three- or four-course rotations, but the principles behind them are generally the same.

There is little value in mere crop rotation as such. To continue growing a succession of ordinary crops on farmland will in time exhaust the soil even more than the usual practice in shifting cultivation of abandoning the farm when the soil shows signs of exhaustion. The great amount of 'leaching' or loss of soluble salts in drainage that occurs on the bare soil surrounding crop plants on tropical soils is being only gradually realized. The soil will therefore continue to decrease in fertility with each succeeding crop, unless some attempt is made to add plant food either by applying manure or by growing and digging in green manure plants. It is essential, in the damper regions, to keep the soil covered as much as possible, so that from Nigerian experience it has been found necessary to include green manures in the rotation at least every two years.

There are scientific reasons why crop rotation is practised, although the economic reasons already mentioned are usually more important. Farmers of all countries know that if the same crop is grown continually on the same piece of ground, the soil will become poorer, and the yield smaller. This is due partly to the removal of plant food and partly to diseases and insect pests which tend to increase every year.

All crops require plant food from the soil. They remove it in the form of lime, nitrogen, potash, and phosphates and other soluble materials. Different crops require different amounts of plant food, some use much and are known as exhaustive crops, others use less and others again, such as legumes, actually add food to the soil.

Of the three essential plant foods already mentioned nitrates promote growth, particularly that of leaves, potash increases the quality, such as the amount of sugar in the fruits and other parts of the plant, while phosphates promote fruitfulness and early ripening.

Different crops use different proportions of the same plant foods, such crops as tobacco, cabbage, lettuce, or spinach plants, which are grown chiefly for their leaves, using more of such plant foods as nitrates, which help in strong leaf formation. If grown continually without manuring, these crops rapidly deteriorate, which, in itself, is sufficient argument for crop rotation. Moreover, if the supply of any one of the three essential plant foods, for example nitrates, is allowed to drop below a certain minimum, no addition of the other two, namely potash and phosphates, even in large quantities, will have any effect. Once the deficiency in the particular plant food, in this case nitrates, is made up, plants rapidly recover and often grow even better than before. Crop rotation, therefore, is a useful practical means of partly preventing any one of these three main plant foods from being unduly exhausted. It is, however, by no means a cure for such losses of plant food, although green manures in the rotation are a help, as will be seen. Only by the addition of proper manures such as compost, farmyard, and other animal manure, and in Europe, artificial fertilizers as well, combined with a proper system of rotation, can the loss of plant food be made good.

Another advantage of crop rotation is that certain crops, for example yams, need particular care, especially weeding, so that the land is more thoroughly cleaned in those years when these

crops are planted. Then there is the effect of various crops on the loose crumbly condition or *tilth* of the soil. By growing a succession of crops on a piece of land the soil becomes constantly worked and turned over, weeds are buried, air and water penetrate deeper, bacterial action increases, and the depth of the soil is increased and its tilth or texture is improved.

Some crops are shallow-rooted and find most of their food in 1 or 2 feet of top soil, while others are much more deep-rooted and obtain most of their food from a depth of 3 or 4 feet, or even deeper, in the soil. If deep- and shallow-rooted plants are grown alternately as far as possible, the soil in the different layers is not exhausted so much, and has time to recover before the planting of the next deep- or shallow-rooted crop. Deep-rooted crops, such as peas and beans, help to open up and decompose the subsoil, as well as to add humus to it by their remains when they die, and are therefore useful in a rotation. Ground-nuts, Bambarra ground-nuts, and edible beans are also useful in the rotation, and besides yielding human food they also enrich the soil. Whenever possible, however, proper leguminous green manures, specially grown for digging into the soil, should be used. A list of suitable plants is given in the chapter on 'Leguminous Green Manures and Cover Crops'.

The value of rotation is realized to some extent by the African farmer, who seldom grows the same crop on a piece of land for two successive years. After clearing the bush he generally plants his most exhaustive crops, such as corn, yams, bananas, or plantains first. These are generally followed in the second and third years by less exhausting crops and sometimes by peas and beans. After this the land is generally allowed to go back to bush.

Under purely African conditions of agriculture prevailing before perennial crops such as coconuts, citrus fruits, bananas, and cacao were specially planted for export purposes, mixed cropping was, and still is, the common practice. It occurs in the usual shifting cultivation system and is used therefore almost entirely for annual crops, which are seldom grown in straight lines. Every district has its own system or systems of mixed cropping, such as yams and Guinea corn in Yorubaland, millet and Guinea corn in Northern Nigeria, and many others.

In the upland rice-fields of the Mende districts of Sierra Leone for example, several crops are planted in small quantities amongst the rice. Beans are grown up the stacks of poles left

dotted about when the rice farm was cleared. Okroes, peppers, and pumpkins are grown amongst the rice, and young cotton-plants follow on, maturing later after the rice is harvested. Similarly beans or ground-nuts are sometimes sown amongst corn, the beans and ground-nuts coming to maturity a few weeks after the corn has been harvested.

Mixed cropping is really a modified form of crop rotation and has several advantages. The land is constantly used, is generally kept weeded, soil wash is partly prevented, and more crops can be raised on one piece of land in a given time. Sometimes, the two or more crops growing together use different quantities of the available plant food, and their roots go to different depths in the soil. In this respect mixed cropping is more scientific than pure cropping. An additional advantage is that insect pests and plant diseases cannot spread so quickly through such farms as when only the same crop is grown and all the plants are close together. One disadvantage of it, however, is that young crops may be trampled underfoot in the harvesting of the older crops.

Allied to mixed cropping, and similar to it in many ways, is the practice of inter-cropping, which, as its name implies, is the growing of certain crops *between* other crops (Plate I *a*). It differs from mixed cropping in that it is applied mainly to perennial crops and to all crops which are planted in rows in between which annual or even perennial crops are planted. Inter-cropping is generally used in the making of special plantations of perennial crops such as bananas, coconuts, oil palms, cacao, and other crops. In special plantations of bananas grown for export purposes annual crops are usually interplanted in the early stages. With woody perennial crops such as cacao, perennials such as bananas, plantains, and coco-yams, as well as the usual annual food crops may be planted.

The advantages of inter-cropping are to shade the delicate young plants or trees of the perennial crops, to cover the soil and prevent soil wash, to keep down weeds, and to grow crops on land that would otherwise be useless.

One of the most valuable methods of soil improvement, however, is by specially growing green plants, particularly leguminous plants, in the rotation or as an inter-crop. When plants are dug in while still living and green, the practice is generally known as *green manuring*, whether they are a crop such as beans or peas planted for the purpose, or even a crop of green weeds. Rich soils often produce a rich crop of weeds when

allowed to stand idle, and these if dug in when green and fresh act as a green manure. Plants put most of their energy into the production of their seeds, and then become woody and fibrous, *when they take much longer to decay than young juicy plants.* If buried before being fully grown plants are very tender and juicy and decay rapidly. Most plants reach their maximum development when in full flower and all their energy is directed to the production of flowers and seeds. The leaves then are most numerous and are bright green and full of sap, which is said to be still 'rising'. If the plants are dug in just when bursting into full flower, and when they are juicy and have not yet become fibrous, the maximum amount of humus is obtained, and they decay rapidly in the soil.

Should the seeds have formed, the plants become dry and woody, and take longer to rot in the soil. Moreover, there is the disadvantage that the seeds germinate and the young plants become weeds in the following crops. When plants that are bad weeds, are buried while in seed, the result is an even larger growth of weeds in the next crop. If, on the other hand, the weeds are buried just before or while they are in full flower they not only form the best green manure but have spent most of their energy without being able to form seeds. Where there is a mixture of weeds flowering at different times it is of course more difficult, but under no circumstances should they be allowed to set seed, and under such conditions it is best to dig them all in while still young. This applies chiefly to annual weeds, that is weeds which set seed and die within one year. With biennial or perennial weeds such as Lalang grass (*Imperata sp.*) and other noxious pests with underground stems, it is much harder. Such weeds are best destroyed by carefully digging out and burning the underground stems in which their reserve food is stored.

Green manuring is the process of digging in leguminous crops, or even non-leguminous plants, which produce masses of leaves and soft stems. Legumes or leguminous plants are those which bear a legume or pod which generally splits along the lower surface, releasing the seeds. Ground-nuts, beans, and peas of all kinds are typical leguminous plants. There are great numbers of cultivated and wild leguminous plants in West Africa.

Long before modern science was applied to agriculture, observant farmers in all parts of the world, for example in China and in ancient Rome, had noticed that soils were often improved after legumes had been growing on them. In West Africa it is not

known as yet whether African farmers are aware of the improvement to soils caused by the growing of leguminous crops, although it will not be surprising if it is one day proved that African farmers have known of this in practice for generations.

It was not until 1838 that scientists began to investigate the manner in which these plants enrich the soil. Many experiments were done and theories proposed until in 1888 two German scientists, Hellriegel and Wilfarth, suggested and actually proved by experiment exactly what took place.

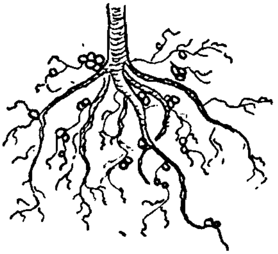


FIG. 2. Nodules on roots of a leguminous plant in which the nitrogen-fixing bacteria live.

The roots of leguminous plants, whether wild or cultivated, if dug up and carefully freed from soil, show numbers of small swellings of a more or less constant shape (Fig. 2). These swellings may be round, oval, or elliptical, while sometimes compound swellings or nodules are produced. These nodules should not be confused with certain swellings, irregular in shape, which are sometimes found on the roots of plants and which are caused by eel-worms. Eel-worms do definite harm to the roots, whereas the organisms in the nodules of legumes do so only temporarily. A leguminous plant can grow quite well without these nodules, which have been found to contain bacteria; but those plants which have bacteria, that is the great majority of the legumes, grow better than those that are without them. The bacteria enter the roots some time after the seed has germinated, and the nodules develop quickly as the plant reaches maturity (Fig. 3). In the early stages of growth the bacterial infection is slightly injurious to the host plant because the bacteria live at the expense of the host. When the bacteria are established and beginning to absorb nitrogen from the soil-air, the nitrogen collected by the bacteria afterwards actually helps the plant.

This is an example of *symbiosis*, or a 'living together', of two organisms, bacteria and plant, which is of advantage to both partners.

Where leguminous plants are grown on a large scale, and on the same piece of land, they have few nodules on their roots in the first year, but the number of nodules gradually increases

each year. Sometimes the bacteria are so numerous that when they enter the root-hairs the plants appear to be, and actually are, sick, until such time as the plant overcomes the attack, after which it profits by the nitrogen collected by the bacteria. When the leguminous plant has died and has either withered where it stood, or, better still, has been dug into the earth, the

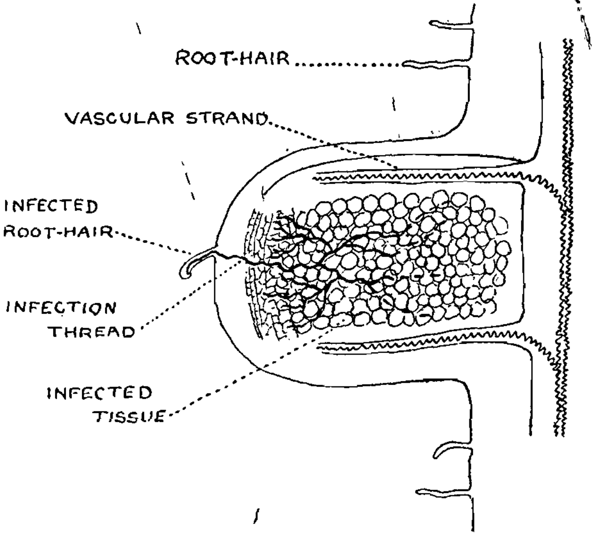


FIG. 3. Cross-section of nodule on root of leguminous plant, showing bacterial infection through root-hair, in the region of which a large swelling or 'nodule' develops. Notice normal root structure and normal uninfected root-hairs above and below the nodule.

soil is thereby enriched in nitrogen compounds, particularly nitrates which are readily soluble in the soil-water and one of the main food materials required by plants.

Another interesting fact about these nitrogen-fixing bacteria is that soil can be gradually inoculated with them. A crop of peas or beans grown on a piece of land for the first time will not be so good as a crop grown on soil where the same beans or peas have been grown before. While these bacteria are generally found in the soil, since wild leguminous plants are found almost everywhere, they are of many kinds, and each species or kind of leguminous plant has its own particular bacteria. It is therefore

impossible to innoculate the soil for ground-nuts by growing cow-peas first, even though both are leguminous crops and are believed to have almost similar types of bacteria in their root nodules. By growing one kind of leguminous crop on the same land two or more times, the soil becomes inoculated with the required organisms which gradually become more numerous and active, and the crop improves in consequence.

Sometimes when special legume crops are planted for the first time, they do poorly, chiefly owing to the absence of the special nitrogen-fixing bacteria suitable for that plant in the soil. The poor results obtained in West Africa, so far, with soya-beans are an example of this. Sometimes such soils are specially 'inoculated' with the necessary bacteria. Soil from a piece of land where the same kind of legumes have been much grown is scattered over the new piece of land to increase the number of useful bacteria there, with good effects on the leguminous crop. This method, however, is very cumbersome, so that in some countries actual preparations or 'cultures' of the soil bacteria themselves are sold under trade names and used for inoculating the soil. It is practically useless to inoculate soils which are deficient in lime, but once there is sufficient lime in the soil these bacteria thrive.

It has been found that the excessive growing of the same leguminous crop, for example clover in Europe, sometimes results in the sickening and weakening of the crop. For this 'clover sickness' as it is called, and other similar troubles, the cure is to rest the land by growing some other and preferably non-leguminous crop for a time. Liming of the soil is also useful. The necessity for changing crops in this way is another argument in favour of crop rotation.

Where the soil is already rich in nitrogen compounds, more nodules are produced and the bacteria are able to collect more nitrogen from the air than the bacteria living in the nodules on the roots of plants growing in poor soil.

Briefly summarized, the German scientists Hellriegel and Wilfarth, who discovered the value of these bacteria to leguminous plants and to agriculture in general, came to the following conclusions:

1. In sterilized[1] soil containing no nitrogen compounds leguminous plants produce no nodules and perish.

[1] If the soil is heated to a high temperature it is sterilized and the bacteria are killed. This has been done by scientists when investigating

2. In unsterilized soil containing no nitrogen compounds nodules are produced and the plants manage to survive.
3. In sterilized soil containing nitrates no nodules are produced, but the plants are able to survive.
4. In unsterilized soil containing nitrogen compounds the nodules are produced and the plants grow perfectly.

Therefore in rich soils, where the proper soil bacteria are present, leguminous plants grow best, and leave the largest amount of valuable nitrogen compounds behind in the soil. This is why legumes enrich the soil in a way which other plants do not, so that by growing legumes in a rotation soil fertility can be increased, and some of the plant food, especially the nitrates removed by the previous crops, can be restored.

One of the main ways in which legumes enrich the soil, therefore, is by the decay of their roots and the addition to the soil of the nitrogen compounds stored by the bacteria in the root-nodules. Even if the whole stem and leaves are removed, or if they wither and die on the surface of the ground, the soil may be richer in nitrogen afterwards. Ground-nuts, cow-peas, and other edible legumes, even though they are pulled up and the fruits removed, enrich the soil in nitrogenous compounds. One of the outstanding problems in the improvement of African agriculture is the discovery or development of a leguminous plant, with edible seeds, which has luxuriant foliage and root systems. This would be a useful step towards convincing African farmers of the value of growing leguminous green manures for the sole purpose of improving the soil. Where the plant is not grown specially for its seed, but is dug into the soil, when coming into full flower, the maximum amount of food is added to the soil, as the nodules are most developed at this stage.

Recent experiments in Nigeria have proved that the decomposition of leguminous crops in the soil takes place much more rapidly in the West African tropics than in temperate regions. This is not surprising as there is a higher average temperature and often more water present in soils of tropical forests, so that bacterial action, and therefore plant decay, is much more rapid. It has been proved that most of the nitrates and other soluble plant foods become available for only a short period during the decay of the leguminous plants in the soil. Unless

the habits of these soil bacteria. Soil can also be sterilized by adding certain chemicals which kill the bacteria present.

the following crop absorbs these plant foods at this period, many valuable soluble salts escape in the drainage water, and much of the good of the green manure is lost.

Much work must still be done in the tropics to demonstrate how green manures, particularly leguminous crops, can best be used. There is always the difficulty of digging them in, but it should be attempted in the way already described. Should the leguminous crop be peas or beans, and be left on the ground until the seeds have been picked, the old plants still add nitrogen to the soil owing to the numerous bacteria in the nodules on their roots.

Leguminous plants also enrich the soil by means of their deep tap-roots, and several long and spreading secondary roots and rootlets. Some of these roots go as far as 6 or 10 feet into the soil, and sometimes penetrate cracks in the underlying rocks and open them so that water and air can enter and continue the breaking up process. They also go deeply into the subsoil, gradually changing it until it becomes more like surface soil. The deep root-system of legumes opens up clay soils and helps the air to enter and act upon the soil particles, which are more quickly changed into soluble plant food. In sandy soil the roots go deeper in search of water, the whole root-system adding humus to the soil when the leguminous plants die. Thus it helps to improve the chemical properties of the sandy soil and its power of holding water.

This opening of the deeper layers of soil and steadily adding food to it is one of the main reasons for the growing of perennial leguminous crops in tropical agriculture. These crops, which are often called 'cover crops' because they are left on the soil to 'cover' or protect it from leaching, are similar to leguminous green manures in many respects, and are described more fully in the chapter on 'Leguminous Green Manures and Cover Crops'.

CHAPTER VI

ANIMAL MANURE

In countries where the pressure of population is great the inhabitants have for generations used the excreta of farm animals for manure, largely because they have been forced to do so or ultimately to starve. The use of excreta has helped to raise the yield of crops, and to replace plant food removed by them. In thickly populated agricultural districts labour is available for handling such manure and applying it to the land. In Europe and America animal manure is carefully collected from the floors of stables, pig-sties, or cattle sheds where it has been mixed with straw, dried grasses, peat-moss, or other bedding material, which helps to absorb some of the valuable liquid from the manure which might otherwise be lost. It is then thrown into a heap in the farmyard, hence its name 'farmyard manure', and is generally allowed to rot during the winter before being applied to the land in the spring. In many parts of the world, where live stock are given 'free range' and allowed to wander freely over farm land, their excreta always help to enrich the soil. Sometimes the live stock are enclosed in fenced fields, or in fenced 'pens', on special crops such as beans or sweet potatoes, and while they feed their excrement is being returned direct to the soil.

In parts of Europe the excreta from the farm sheds are carried direct to the field and dug in. This would be possible and useful in West Africa where 'bedding' in the form of dried grass is not generally used in live-stock pens. It would be good, however, if West Africans learned to use such bedding for their animals and to store their manure, as is done in Europe and America. As the rainfall is heavier than in Europe it is even more essential in Africa to keep such manure under cover. Where conditions are dry the manure should be kept watered as this helps it to decay more rapidly.

Although in many countries farmyard manure has been used for centuries, it is only recently that scientists have proved how valuable it is to the soil and what useful plant foods it contains.

In China and Japan for generations all animal excreta have been saved and applied to the land. In many parts even human excreta are carefully collected and used as a manure for crops. To many the use of human excreta as a manure for crops comes

as an unpleasant shock. In recent years, however, great steps have been taken in Europe and America to save human excreta, which had previously been lost by dumping into the sea, or into rivers, which were sometimes made foul and dangerous in consequence. In many places this waste material from towns, generally known as sewage, is now carefully treated scientifically, so that most of the odour and unpleasantness is removed before it reaches the land, and the crops grown afterwards are safe for human food.

The use of human sewage as manure has hardly occurred in West Africa as yet, and its careless use on the land without proper treatment would result in the spread of dysentery and other dangerous diseases. At Achimota College, on the Gold Coast, a sewage disposal system is installed. The purified liquid is used in irrigation channels on the College Farm for the growing of vegetables and fruit. The treated solid portion, known as 'sludge', is applied to the land from time to time as a harmless and practically odourless friable grey solid, which is a useful manure.

It is out of the range of a simple text-book of this kind to discuss the value of sewage as a manure, except to say that it contains the same types of plant food as are found in animal or farmyard manure.

Animal excreta may be liquid or solid. In West Africa where domestic animals are allowed to roam freely, the liquid portion is generally wasted and even the solid portion is frequently not used.

The liquid portion, or urine, contains different kinds of salts in solution, common salt occurring in small quantities. A substance known as urea is also found and is rich in nitrogen and quickly decomposes to compounds of ammonia and to nitrates. Potash salts also occur in urine, and these and the nitrates formed from urea are valuable plant foods. Now, as we know, plants are only able to take in food from the soil when it is in solution. In urine the substances are largely in this dissolved form, and are also useful as plant food. As urine contains even more of the valuable active nitrogen compounds than faeces, much plant food is lost when the urine is wasted. Even when applied to the soil much of it drains away before the plant can use it. Therefore every effort should be made to conserve this liquid.

One immediate effect of soluble nitrogen compounds on the

plant is an increased growth of leaves, and should diluted urine be constantly applied to a crop or a plant, many healthy rich green leaves will be produced. In Europe gardeners sometimes keep a special barrel into which is put farmyard manure, both liquid and solid. After some time this gradually decomposes and water is poured into the barrel, dissolving the soluble portion of the solid manure, as well as the original and now partly decomposed urine. The resulting deep brown liquid is known as 'liquid manure', and is used to water plants. As it is rich in soluble plant foods, particularly in nitrates, it produces remarkable results on the plants to which it is applied. After some time the gardener adds more water to the manure tub and later removes a second lot of liquid manure which is not quite so rich in dissolved plant food as the first lot.

If liquid manure is applied undiluted in too large quantities, actual harm may be done and the plant withers and appears to have been burnt. This is mainly caused by the strong solution in the soil being more concentrated or denser than the cell-sap in the root-hairs, until the cell-sap actually leaves the root-hairs and the plant wilts. This is another example of what is known in botany as *osmosis*, except that it works the wrong way round and water leaves the root-hairs causing a state known as *plasmolysis*, due to the shrivelling up of the contents of the plant cells. The main injury done to plants by the addition of too concentrated liquid manure, however, is probably ammonia poisoning rather than plasmolysis.

The solid portion of farmyard manure, or excreta, is also rich in plant food, except that it is mostly in an insoluble form, so that the plant cannot use it. A small proportion, nevertheless, is soluble and can be absorbed by the roots of plants, while the remainder is gradually turned into a soluble form by the action of soil bacteria. Most of the solid farmyard manure which first dissolves is transformed into nitrates, and portions containing potash are generally longer in becoming soluble. Nevertheless, dung is an excellent potassic manure. Besides nitrates [illegible] potash, farmyard manure also contains phos[illegible] main food requirement of plants. [illegible] to dissolve and remain longer in [illegible] nitrates or potash; they help in building t[illegible] plants and in good root development.

The solid excreta consist of the undigested remains of the food of domestic animals. As farm animals feed almost entirely

on a vegeterian diet consisting of grass, leaves, seeds, fruits, and roots of all kinds, the solid excreta consist mainly of undigested portions of plants.

The seeds eaten by animals are sometimes untouched or only partly acted upon by the digestive juices. This depends upon the thickness or permeability of the seed-coat, on the condition of the animal, and whether its teeth or digestive organs are working properly. Small grain such as Guinea corn or millet sometimes passes whole through a pig's digestive tract.

The saliva and digestive juices of animals all act on these plants and seeds, dissolving and using the parts valuable as food, such as the sugars, fats, and starch, as well as the body-building portions known as proteins. The amount of food material absorbed depends largely on the animal's physical condition, and also upon its age. Healthy animals absorb more of these nutriments from their food than animals in poor condition. Young animals also use more of them than older animals, because they have bones, muscles, and new tissue to build. As bones need the lime and phosphates found in the food, these are partly removed and used by the animal, and the same applies to the nitrogen-containing proteins, which help in muscle formation. Therefore the excreta of a young animal are poorer in plant food than those of an older animal, and the excreta of a cow producing milk are also poorer than that of a cow not producing milk. Older animals take out only as much food material as they require for the repair of muscles or body materials and the strengthening of bones. The older the animal, the less phosphates does it absorb from its food, and consequently the more passes through in its dung, which is enriched thereby.

A working animal uses more food material than an animal enclosed in a shed, or an animal which is being specially fattened, and its excrement is therefore poorer.

The fibrous portion in plants eaten by stock is sometimes completely dissolved, but the tougher fibres are only partly softened and decomposed, and sometimes they pass through the animal's digestive tract practically untouched. If the faeces of grass-eating animals, such as cattle or horses, are examined, small fibrous portions are seen to be all that remains of the plant fibres. These fibres have less food value for the animal. As they decay gradually in the soil they are the last part of the excreta to turn into available plant food. While the soluble nitrogen compounds are mostly released in the course of a few

days, the potash salts in a few weeks, and the phosphates in a few months, the insoluble fibres sometimes remain in the soil, practically unchanged, for months after the application of the farmyard manure to the soil, although they do eventually decay.

Between the two extremes of the rapidly soluble nitrogen compounds and the slowly decaying fibrous portions of the excreta is the main portion which continues to decay and form soluble plant food over a period of many months. It is this continual supply of available plant food that dung provides in the soil which makes it so valuable to the farmer. Also dung often helps to improve the physical condition of sandy soils by adding humus to them, and of clay soils by helping to open up and aerate them.

Litter or bedding in the farmyard manure, consisting of straw or dried grass, decomposes even more slowly than the fibres in the excreta. The bacteria present feed upon the more soluble portions, especially the nitrates, and then attack the more insoluble fibre in the litter and break it down gradually into more soluble compounds. Therefore, in farmyard manure, such dried grass or straw decomposes more quickly than in the soil, especially if there is plenty of urine present. Then, when the farmyard manure is added to the soil, the decomposing litter helps to form useful plant food, even though it is the last part of the manure to decay.

Besides these plant foods, the faeces also contain a certain amount of lime. Plants contain lime, part of which is used by the animal in building up bones and body tissues, and the remainder passes out in the excreta, where it is used again by the plant.

The manure of different domestic animals varies in the amount of plant food it contains, depending on the nature of the food and the amount of food materials absorbed by the animal. Generally larger animals, like cows and horses, have poorer excreta than smaller animals such as sheep, pigs, and poultry. In the tropics goats eat the leaves and stems of shrubs as well as grass, so can hardly be compared with sheep, which are almost entirely grass feeders. Cows and horses are able to feed on larger and tougher grass than sheep, and therefore their excrement contains more fibres and is consequently not so valuable as plant food. When horses are specially fed with grain such as Guinea corn or oats, their manure is richer because grain or seeds are more nutritious than ordinary grass and

contain less fibre. As sheep feed on smaller and more tender plants, they have less fibre in their dung, which is slightly richer in plant food than that of cattle. Pig's excreta resemble human excreta, because pigs, like men, are omnivorous and eat animal as well as plant substances. Also, as their stomachs are unlike those of ruminants, they do not eat such quantities of fibrous foods. In countries where pigs are carefully kept and properly fed, their excreta can be quite rich, but in West Africa, where they run almost wild and feed on any refuse, their manure is correspondingly poorer.

The excrement of domestic birds, such as hens, ducks, and turkeys, is richer than that of all other forms of live stock for the following reasons. First, in poultry the liquid and solid portions are combined and are given off at the same time, so that the rich urine, containing the valuable nitrogen compounds, is not lost to anything like the same extent. Secondly, poultry feed largely on grain, such as maize, rice, and grass seeds, while some imported birds are fed on special poultry mash, bran, or other rich food. Consequently poultry excreta contain a much smaller percentage of indigestible fibres and therefore a higher proportion of plant food more readily available in soluble form. In fact the amount of undigested fibre in poultry excreta is negligible. Thirdly, poultry manure is generally richer in lime. Most people know how readily hens eat any substance containing lime, such as egg shells and the broken shells of oysters and other shell-fish. If no lime is available, they will peck even at the lime-wash on the borders of a tennis court or playing-field. The presence of lime in their excreta can be readily noticed, as hens' excreta are often whitish. Poultry manure is therefore the richest of all, but it is almost universally wasted in West Africa.

In the thick forest country cattle and horses are seldom kept because of the tsetse-fly. Small flocks of sheep and goats generally abound in the towns and villages, and pigs act as scavengers where the medical authorities have not ordered their removal. But in almost every African compound poultry are found, and primitive hen houses, sitting and laying nests are provided for them. Yet the excrement is usually left undisturbed, or, if it is cleaned out, it is taken with the sweepings of the compound, including the wood-ashes and the sheep and goat excreta, to the kitchen or village midden, where the usual weeds of the village compound thrive in luxuriance. This useful compound

manure or refuse is often allowed to become a nuisance by attracting disease-carrying flies. These kitchen sweepings are, however, of great value and should be preserved, as they are in most countries where agriculture receives the attention that it should. They could well be collected into pots or into empty petrol tins, and applied either daily, or when the tins are full, to the vegetable garden in or near the compound, or to the school garden. They should be scattered over the surface of the soil, and dug in the same day. This prevents the loss of nitrogen into the air and also the moisture in the soil will help to decompose the manure more rapidly than if it was left on the surface.

The West African farmer, however, is not ignorant of the use of the excrement of domestic animals as manure; it is used in certain districts. Dagomba and Hausa farmers, for example, manure certain crops such as onions and tobacco with animal dung.

Nevertheless, far more use could be made of farmyard manure in West Africa.

It is impossible to leave the subject without mentioning other forms of animal manure. While farmyard manure is undoubtedly the most valuable and soluble kind of animal manure, other kinds do exist. One of the best is animal blood, which is rich in nitrogen compounds as well as in potash and phosphates, and which rapidly decomposes and forms plant food in the soil. In Europe the blood of animals killed in slaughter-houses is collected, dried, and powdered, and sold in the form of an unpleasant-smelling reddish-brown powder, known commercially as 'dried blood', and used as a fertilizer for crops. The hair, skins, and horns of animals are also of some value as manure, but are hard and are slow in changing into a soluble form. Such slow-acting manures would be of more value for perennial crops such as cacao than for annual crops. The bones of animals, which are rich in lime and phosphates particularly, are useful as plant food, but unfortunately they take a long time to change into a soluble form before plants can use them. Commercial firms have therefore discovered that if the fat and gelatine are removed from bones which are then ground up, steamed, and digested, they make useful, though rather slow-acting manure; they are sold under names such as 'bone-meal' and 'bone-flour'. Sometimes the ground-up bones are specially treated with strong acid, such as sulphuric acid, and the soluble portions are

largely or partly dissolved, so that they are more quickly dissolved and therefore available as plant food. The treated bones are then ground to a powder, and sold in sacks to farmers as a fertilizer under the name of 'dissolved bones'.

In some parts of the world where fish are caught in great numbers and prepared for the market either by drying, smoking, salting, or canning, the intestines, heads, tails, and other useless portions were at one time thrown away, and it was often a problem how to dispose of them without causing bad smells and insanitary conditions. Since scientists have proved that such fish-refuse is of value as a manure, much of this scrap material is now used by commercial firms who dry, deodorize, and powder the fish-waste, which is then sold to the farmer as fish manure. It is a useful manure and is rich in nitrogen compounds and phosphates and does not take long to decompose in the soil.

In West Africa, especially along the coast in the fishing towns and villages, much of this fish-waste occurs. When the nets are pulled ashore those fish which are too small to be dried or smoked, and the intestines of larger fish, are scattered broadcast on the beach, attracting innumerable flies and causing most insanitary conditions in the fishing villages. If this fish-waste could be collected and dug into the land as soon as possible, one other form of valuable plant food could be made use of in West Africa. This is actually done in parts of the Awuna district on the Gold Coast.

Another manure known as guano, and consisting mainly of the excrement of sea-birds, is imported into Europe from Peru and some also from islands in South-West Africa. Where the climate is dry and the excreta have not been too far leached by the rain, this manure is rich in phosphates, potash, lime, and sometimes in nitrogen. In the Quittah district on the Gold Coast certain islands in the lagoon are covered with sea-birds and the farmers collect the excrement or guano and apply it to the land. In that district the excrement from bats living in empty houses is also carefully collected, and even sold, and is generally applied to the onion crop.

CHAPTER VII

OTHER MANURES

ONE of the most useful methods of utilizing vegetable remains or animal refuse in the tropics is by what is known as the compost heap, which is fortunately becoming increasingly popular in school gardens.

This consists of dead plants, leaves, and plant rubbish of all kinds stored in a heap where it can decay and be added to the soil later as a type of manure. Weeds from garden paths and plots, dead leaves raked or brushed up, the clippings of garden hedges, or the prunings of trees are put into a heap as near the centre of the garden as possible. Compost heaps are generally oblong in shape and are made in layers. First a layer of leaves, hedge clippings, or weeds, 6 inches to 1 foot in thickness, is made and pressed down evenly with the feet. A layer of soil of the same thickness is then placed on top. Another layer of garden rubbish is added, and so on, until the heap is 5 or 6 feet high. If sweepings from the compounds containing wood-ashes, or the excreta of poultry, sheep, and goats or other animals are added, the compost is enriched, and the animal humus helps the plant remains to decay.

The advantage of alternate layers of plant rubbish and soil is that the soil layers contain bacteria and other tiny organisms which act upon the plant rubbish and help it to decay. The soil also mixes with the plant humus and helps to hold the moisture.

It is advisable to turn the compost heap two or three times before it is applied to the land. Such turnings admit more air and oxygen without which many of the useful bacteria would become inactive. Also, each turning helps the decaying leaves and the soil to become more thoroughly mixed up and to decay more quickly.

As the work of decay or breaking down the complex plant compounds into soluble materials useful as plant food is carried on by the bacteria in the compost heap, it is best that they should receive their proper conditions of air, moisture, and food. If decomposed urine, sulphate of ammonia, powdered bones, lime, or any other mainly soluble plant food is added to the heap, the bacterial action increases and the process of decomposition is hastened. The bacteria which attack the more insoluble cellulose in the compost heap require nitrogen so that

to add anything containing active nitrogen compounds to the heap will result in quicker decomposition. A material known as 'Adco' is sometimes recommended for this purpose and is composed mainly of calcium and nitrogen compounds, with a little phosphate. This substance, by feeding the bacteria, enables heaps of the tougher plant wastes, green stems, husks of fruits, and the like to be decomposed more rapidly.

Compost heaps should be watered from time to time so that they are kept constantly *moist*, not wet, as otherwise the layers of plant rubbish near the top will become dried and will therefore take much longer to decompose than in those parts of the heap where conditions are moister.

After a few months of regular watering and occasional turning, the plant rubbish in the compost heap has decayed sufficiently for it to be applied to the soil, being spread evenly over the surface and dug in when possible.

These compost heaps are the tropical equivalent of the properly cared-for farmyard manure heaps on European farms. In West African forest country, where animal manure is scarce and difficult to collect, the compost heap, composed chiefly of vegetable humus, is one of the main solutions for adding to the soil the humus so continually removed by the destructive methods of burning the rubbish in shifting cultivation, and of burning the bush in the grassy regions.

Artificial Manures

In Europe and America populations have moved into great towns, and agricultural produce whether in the form of grain, roots, fruits, meat, wool, or milk has been taken from the land and sold in the towns. All this produce represents valuable food material, much of which originated from the soil and which, instead of being returned to the farms from which it came, is carried away in the sewerage of the great cities. In countries where most of the people live on the land, however, this produce is largely returned to the soil in the form of manure. Other sources of plant food were investigated to prevent this excessive waste. Ordinary lime or chalk had been in use for generations. With modern science, however, men have come to realize why lime improves certain soils and therefore the use of it has increased, and it is now applied in a finer and more 'available' form.

Other mineral material was found to contain plant food,

particularly subtances known as mineral phosphates, derived from rocks rich in phosphate found in different parts of the world. In Nigeria certain soft phosphate deposits occur and have been ground up and tried as a soil fertilizer, so far with only poor success. Other phosphates, however, are richer and are worth applying to the soil in a powdered form. Large quantities of mineral phosphate are now exported from Morocco. Such phosphates, however, are slow acting and only become soluble gradually, so that they are often treated with acids such as sulphuric acid and sold under the commercial name of 'superphosphate'. The phosphates in superphosphate are much more readily soluble than those in ordinary rock phosphate and therefore superphosphates act quickly and more effectively when applied to the soil. Although acid has been used in its preparation superphosphate has no acidifying effect on the soil. Another commercial phosphate fertilizer is dissolved bones which has been described in Chapter VI. Another fertilizer known as 'basic slag', which is a by-product of the steel-making process, is an excellent phosphatic fertilizer. As it also contains lime it is alkaline and therefore sweetens and enriches the soil. Basic slag is also slow acting and gives best results with perennial crops such as cacao, coffee, and others.

Muriate of potash is probably the best known potash fertilizer and gives good results on light soils, as clay soils usually contain plenty of potash. Chemical potash fertilizers generally dissolve quite easily in soil-water and are therefore fairly quick acting.

Nitrogenous fertilizers are generally the quickest in dissolving and acting and are therefore often used on annual crops. Sulphate of ammonia, nitrate of soda, calcium cyanamide, and ammonium phosphate (really a 'double' fertilizer as it contains phosphates as well) are amongst the best known artificial fertilizers rich in nitrogen.

Most of these fertilizers have been tried out on agricultural experimental stations in West Africa, and the nitrogenous ones have so far given best results.

Generally speaking, it has not yet been found worth the expense of importing artificial manures, especially those containing potash and phosphates, and as capital is required to invest in them, there is little immediate likelihood of West African farmers taking them up. Should any one wish to increase the yield of his farm or garden with such fertilizers it is

best to follow closely the experiments carried out with them by the local agricultural department and to seek the advice of its officers before spending money which might otherwise be wasted.

There are several 'compound fertilizers' on the market, which claim to contain properly balanced amounts of nitrogen, potash, and phosphates, but the farmer should be thoroughly familiar with the nature and requirements of his own particular soil before buying such fertilizers, however attractive they may seem to be.

CHAPTER VIII

WATER IN THE SOIL

WHAT happens to the water which falls in such torrents during West African rainstorms and tornadoes and during the rainy season depends largely on the slope of the ground and the composition of the soil, whether it is pervious like gravel and sand, or only slightly pervious like clay, or porous like humus. On steep slopes water tends to run off the surface more, but on gradual slopes or on level land most of it, at first at any rate, sinks into the soil. During a rainstorm the soil is often sodden or wet, with free water on its surface; yet soon after the rain ceases the soil looks more or less normal. Most of the water which is absorbed runs into the subsoil, dissolving from the soil some of the soluble plant food which is afterwards lost in the drainage water. Much plant food is lost in this way, and it is difficult to see how it can be prevented. The heavier the rainfall the greater the loss of soluble plant food. In some districts in Sierra Leone, where the rainfall is between 100 and 200 inches per year, not only is much surface soil washed away, but much of the soluble portion of the soil and the underlying rock is washed out or 'leached' out in the drainage water, so that a hard layer, generally known as a 'laterite pan', is left. The soil above this pan often consists of only 3 or 4 inches of gravelly substance, rich in iron, but poor in plant food, while the laterite pan itself has had most of its soluble plant food removed also. It seems strange that in such regions of heavy rainfall, where one would expect soil to be rich, it is often much poorer than in dry districts, and the heavier growth of vegetation in these wet districts is almost entirely due to the amount of water always present. In the drier districts the soil is often very fertile and the problem is rather one of lack of water, and when such soils are irrigated, wonderful crops may be obtained.

Most of the drainage water then contains soluble plant food which is carried away in streams and rivers to the sea, where most of it is lost to plants and only adds to the salt in the sea.

Almost as serious a loss of plant food occurs in other parts of West Africa owing to the heavy surface wash which occurs, especially where the soil is at all sloping. The heavy rain, often driven by a strong wind, beats the soil and loosens the surface layers, which are quickly washed away down the slopes. This

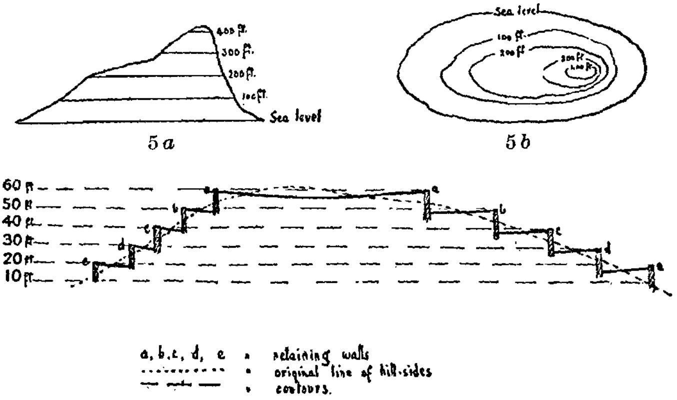
surface wash or erosion is one of the most serious obstacles to good farming, not only in West Africa, but in all tropical countries, and to a smaller extent in sub-tropical and temperate countries as well. The surface-layer of soil is richest in plant food and humus and has been formed only by long periods of the action of the oxygen of the air, the dissolving influence of water, and the decaying remains of generations of plants. On steep slopes particularly, land should never be cleared of bush if it can be avoided. Where hill-sides are covered with thick forest, scrub, or even grass, the danger of soil wash is greatly lessened. When trees grow on hill-sides their roots, spreading in all directions and interlacing with those of neighbouring trees and shrubs, help to hold the soil. Moreover, their leaves fall to the ground continually, forming humus and enriching the soil, so that the older the forest the richer and deeper the soil; the humus acting as a sponge and holding the water. To clear such valuable forest is almost madness as it means exposing a bare hill-side to the mercy of the lashing rainstorms. In the rains deep gulleys are formed by surface streams of water, the more or less infertile subsoil and even the bare underlying rock is exposed, and probably never again will the soil reach its former fertility. (Fig. 4 *a*.)

Further surface wash can be prevented by planting some crop which will hold the soil. Peas or beans, sweet potatoes, or some 'cover' crop will help for the time being, but it is best to replant the whole hill-side with forest timber or firewood trees. Seeds may be obtained from the local forestry or agricultural departments. The deepening of the destructive gullies can be partially prevented by placing across them a series of small dams, made of lines of poles driven into their beds at every few yards. Across these lines of poles brushwood or twigs are fixed so that when the rain comes much of the loose surface soil is caught behind the dams which gradually fill up with the silted soil. (Fig. 4 *b*.) This is only a temporary measure, however, as once the dams are silted up erosion may occur again, after which additional dams should be made.

A further improvement on the series of dams placed across the gullies is the terracing system. This consists in the making of a series of terraces along points of the same height on the hill-side. (Figs. 5 *a*, *b*.) In other words a series of ridges is made along the same contour lines, so that it really consists of a number of 'steps', each step being continuous and at the same level

FIG. 4. (*a*) Erosion. Deep gully worn by rain in advanced stage. (*b*) Gully in early stage of formation. Method of checking further erosion by brushwood dam.

all round the hill-side. (Fig. 5*c*.) Each terrace must be carefully surveyed with a theodolite, or proper surveying instrument, before really satisfactory results can be obtained, although quite good work can be done with a spirit-level and boning-rods only. To guess areas of the same level with the unaided eye, while of some help, generally results finally in unsatisfactory terraces which are unequal in height, so that the surface water quickly



5 *c*

FIG. 5. (*a*) Cross-section of hill showing contour lines. (*b*) Plan of same hill showing contour lines. (*c*) Diagram to show method of making terraces with retaining walls along contour lines.

bursts through their lowest points and washes away the soil once more. When permanent plantations or farms are made on hill-sides, some kind of terracing is absolutely necessary if most of the valuable surface soil is to be saved. (Plate I *b*.) In European tea plantations in Ceylon and in plantations in other parts of the tropics, terracing on hill-sides is widely used, and the slopes of the mountains in the thickly populated islands of Java and Sumatra are covered with a wonderful system of terraces. The natives of these countries, alive to the dangers of erosion, had practised terracing for generations before Europeans came, and are even able to grow on these terraces crops needing irrigation, such as swamp rice. This shows how thoroughly they were originally made. Terracing on hill-sides is practically unknown in West Africa, although primitive attempts are found in places in Northern Ibo country in Southern Nigeria.

After a series of points on the same contour have been fixed, a low ridge or wall is constructed, and when possible strengthened with stones. These ridges or terraces are raised and the soil from the hill-side above them is generally used in such a way that the soil behind the ridge itself is kept slightly higher than the soil which was originally higher up. This means that the lowest point on each terrace occurs just below the retaining wall of the terrace above. In this way a series of slightly cup-shaped depressions is formed on the hill-side, so that most of the surface water is collected in these hollows and behind the retaining walls, where it gradually sinks into the soil instead of flowing down the hill-side. In particularly heavy rainstorms, however, the retaining walls are sometimes broken down at their lowest parts, and the free surface water rushes from terrace to terrace, breaking down the barriers at the weakest points as it goes, and carrying destruction before it. To prevent this the retaining walls should be kept in a state of continual repair.

The question of terracing hill-sides is so large and so beset with difficulties that the reader is referred to other aspects of the problem in larger works on tropical agriculture.

In hilly districts, however, farmers are often obliged to make their farms on sloping ground. In such districts land with the gentlest slopes should be chosen for farms, preferably in the most sheltered positions, not exposed to tornadoes or driving rain. Such farms should be kept as small as possible, and ten small farms of one acre each, with untouched 'bush' between them are better than one large farm of ten acres. In a small farm there is less soil wash, and the surface water has not the time nor the area necessary to gain in velocity and power. Where large clearings are made, however, much soil wash can be avoided if the farmer leaves narrow strips of untouched bush across his farm, such strips being along the same level or contour. These act as small retaining walls or terraces and can often prevent much soil wash, though in heavy rainstorms they tend to be flattened down with the rush of water over them. Even when a series of small farms is made, it is advisable to leave these narrow strips of shrubs or grass to prevent too great a surface wash.

Where the slope is only slight, rapid erosion of surface soil often takes place when the ground is cleared ready for planting crops. On Ibadan Agricultural Station a system of ridging has

been adopted which has been found effective. (Plate II *a*.) This method of ridging is now spreading and is to be recommended.

Care should be taken in the planting of crops. While it is necessary to plant such crops as yams or corn which do not spread over the surface of the soil, much of the soil wash caused when these crops are planted by themselves or together could be prevented if they were interplanted with more spreading crops which would help to hold the surface soil. Beans, peas, sweet potatoes, ground-nuts, pumpkins, water-melons, and similar crops all help to keep the soil covered and to prevent surface wash.

Other problems are created by excess of water on level soil. Huge areas of land in West Africa are flooded for weeks or even months in the rainy season. The flats beside rivers, level soil in valleys and plains, water-holes and depressions in otherwise practically waterless plains become flooded in the wet season, often with disastrous results to crops, although swamp rice generally flourishes under such conditions. The richest soil is generally to be found in valleys and beside rivers, but when such soils are covered with even a thin layer of water, the effect on farm crops growing on them may be fatal. Most plants cannot grow in waterlogged soils because they are too cold and their roots cannot get the heat required for their growth. But it is the absence of air, particularly oxygen, round their roots which has the worst effect. Crops growing in flooded areas have a wilted and unhealthy appearance and look half drowned, as indeed they are. That is why cacao and other crops generally do best on gentle slopes rather than on the level, for while the flats are better in the dry season, the effect of flooding is disastrous to the plants in the wet season. There are two ways in which this flooding of level land in the wet season can be prevented, and they are both methods of drainage. The first method is by digging a series of channels or surface trenches leading from the slightly higher to the lower ground. A series of side or 'feeder' trenches can be joined up with the main channels until much of the surface water can be drained back into the streams and rivers where it belongs. This work means a good deal of expense and trouble at first, but is worth while in the end. The upkeep of these drainage channels consists of keeping them free of weeds and mud each year so that they can continue to act and be of service for many years.

The second method of drainage is more complicated and

expensive, and is known as tile-drainage; it is the method adopted in up-to-date farms in other parts of the world. Trenches 2 to 3 feet or more in depth are dug and earthenware pipes are laid down in them. The side drains are joined to the main drains in the same way as that described for surface drains, and the rows of pipes are then covered in. Tile drains help to make a damp soil drier, just as surface drains help to remove excess surface water. Both systems have a beneficial effect upon the soil by removing excess water and enabling air to penetrate to the soil. These two methods of drainage assume that there is lower lying land beyond the farm, which is by no means always so. Then by making a series of broad ridges and furrows so that the water collects in the furrows and the land on the ridges is drier in comparison, healthy plant growth may become possible. This system of ridging and furrowing the ground is the cheapest way of making low-lying swampy land suitable for growing crops.

Crops grown on land that has been properly drained thrive, largely because the soil is better aerated. Soil bacteria flourish better and humus is decomposed more quickly and efficiently so that the plants are able to make much more use of the soluble plant food present in such rich soil than they would if the soil were waterlogged. Also the soil becomes less sour and acid, and if an application of lime is made at the same time the amount of plant food released is increased.

A slightly different problem arises in those waterlogged soils which occur along the sea-coast, generally in the neighbourhood of salt water or brackish lagoons. These areas are usually covered with mangroves which advance gradually into the water, reclaiming the muddy flats as they go. These flats become covered with fleshy-leaved or succulent plants and finally by coarse grasses. Such tracts are known as salt marshes and are even more unsuitable for farm crops than fresh-water swamps. Not only is the soil often waterlogged, and therefore cold and lacking in the air which plants need for the healthy growth of their roots, but the water itself is salt. Although common salt and other salts in small quantities are needed by most farm crops, the excess of salt found in these swamps means that few farm crops can thrive. It is not the effect of the salts so much as the fact that they form a solution which is stronger and denser than the cell-sap in the root-hairs. Therefore, instead of the soil-water moving into the root-hairs (by the process known

as osmosis), the cell-sap in the root-hairs, being the weaker, moves towards the salt solution in the soil, and the plants wither and die. That is why the plants which seem to thrive best in such positions have fleshy leaves like desert plants. To all intents and purposes these plants are living in a desert, for though there is plenty of water present, it is unsuitable and cannot be utilized. By having fleshy leaves and storing rather than giving off water, such plants take in very little of the salty solution and therefore are able to live under such conditions.

The best treatment of salt marshes is, as in fresh-water marshes, to drain off the surface water by ridges and furrows, first by surface trenches, and later, if possible, by the use of tile-drains. At first such reclaimed or drained salt marshes can support only poor farm crops, owing to the large quantity of salt still left in the soil, but gradually the degree of saltiness grows less, and more and better crops can be grown. Lands that have been salt marshes in the past are generally deficient in calcium and the addition of lime improves them for farming purposes. The addition of calcium sulphate (gypsum) also helps to improve the quality of the clay in salt marshes. Lime and gypsum both help to change the infertile 'sodium clay' which is also sticky and difficult to work, into the less sticky and more fertile 'calcium clay', the excess of harmful sodium salts formed being washed out in the drainage water.

In the Scarcies rivers district of Sierra Leone great areas of swamp rice are grown in mangrove swamps, and such swampy soils, once reclaimed, gradually become very fertile, owing to the amount of rich sediment and clay present.

Some farm crops can endure a certain amount of salt in the soil better than others. Okro and onions can both be grown and thrive quite well in such reclaimed areas near the coast.

Having dealt with four kinds of water in the soil—water held by the colloidal substances in clay and humous soils, drainage water, water removed by surface wash, and free water lying on the surface of the soil—there still remains one other kind, which is known as capillary water. This is water that remains in the soil after the main drainage water has gone, and can be compared to the water adhering to the sides of a glass which has been emptied, except that such water in the soil is left clinging to all the soil particles. Each particle of soil is surrounded by a thin film of water which adheres to it by a force known in physics as surface tension or capillary attraction. (Fig. 6.)

The spaces between the particles of soil, therefore, are largely filled with air, except deep in the soil where free water is still found. As the water gradually drains away, the level of the free water in the soil drops, and air enters to take its place. Therefore in most soils, except waterlogged soils, there is plenty of air between the soil particles, and so the roots of plants can get the oxygen they need to grow properly. As the tiny root-hairs come into contact with the various soil particles the tiny films of water surrounding them are attracted to the root-hairs and quickly surround them also. The root-hairs, being covered with a delicate layer of soil-water, absorb it easily, and more water is attracted to the dried surface of the root-hairs from the adjacent soil particles which, in their turn, obtain their surface films of water from the soil particles touching them. This passage of film water from particle to particle in the soil, known as capillary attraction, is very important to agriculture and its action is not fully realized by most people. Plants probably obtain more of their moisture from the soil by means of these tiny films than they do from free standing water in the soil, and continue to obtain their water in this way for days and weeks, and sometimes for months after the free water in the soil has disappeared.

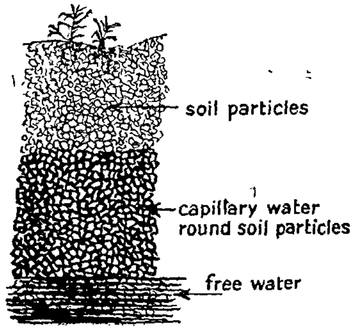


FIG. 6.

This movement of capillary water takes place continually and is effective in all directions in the soil, horizontally as well as vertically. It is often noticed, for example, that plants in a crop growing in the neighbourhood of a tree, even if not actually under its shade, do not thrive so well as those farther away. The reason is that so much of the capillary water in the surface-layers of the soil moves sideways in the direction of the numerous rootlets of the tree, so that the plants suffer in consequence.

As the water surrounding the surface particles of soil evaporates, fresh films of water are attracted to these particles from the moist grains of soil beneath or alongside them. As these particles lose their film water, new film water is attracted to

them from adjacent soil particles again, so that a continual 'chain' of water can pass from the soil particles deep down in the soil, where the level of free water is, up to the surface of the soil where it escapes as water vapour. Thus water is able to move upwards *against* the force of gravity, so that in this case the force of capillary attraction is stronger than that of gravity. This upward passage of water takes place in all soils, but its speed and efficiency depend largely on the composition of the soil. Where the soil particles are mostly composed of gravel or sand, they are comparatively large and far apart, so that the film water does not pass so easily from particle to particle. If such soil is rolled or compressed, the particles come into closer contact, and the film water moves upwards more quickly; hence the practice of rolling sandy seed-beds when seeds are first planted. In loam and clay soils, the soil particles are smaller and closer together, and more of their surfaces are in contact, so that capillary attraction takes place much more easily. The large air spaces and the poor capillary attraction in sandy and gravelly soils, combined with the ready drainage, result in a rapid loss of water from these soils. In compact clay soils, on the other hand, drainage is slower, because the colloids in the clay retain the water and the particles tend to stick together in masses. When clay soils dry out, however, they tend to crack, slightly at first, then large cracks gradually appear along their surface. If long pieces of grass are pushed into these cracks it will be found that they penetrate to a depth of 2 or 3 feet. Often these cracks continue to a depth of 5 or 6 feet or even more into the subsoil. This is a serious matter, as it means that much of the water from the subsoil, instead of climbing slowly from particle to particle by capillary attraction, escapes into a crack 5 or 6 feet beneath the surface, where it rapidly rises to the surface as free water-vapour. In dry countries this loss of subsoil water is very great, and it is only by a careful study of the movement of capillary water in the soil that the best method of preventing such wholesale waste has been discovered. The longer such soil is left undisturbed, the wider, deeper, and more numerous do the cracks become. Besides, when soil is left undisturbed the capillary water tends to move upwards along the easiest channels, that is, where the particles are closest together. By cultivating such soil with a hoe, cultivator, or other tool, the soil particles are disturbed and shifted farther apart, so that it is more difficult for the film water to move from particle

to particle until it reaches the surface and is evaporated. Therefore such water is retained longer for the use of the crops grown in the soil. The oftener the soil is disturbed in this way, the more is the rapid movement of film water reduced.

The chief value of disturbing the soil by hoeing, however, is in forming what is generally known as a 'dust-mulch' on the surface. The first and most obvious advantage of such a surface layer of loose soil is in filling up the cracks and forming a 'blanket' of dust over them so that subsoil water cannot escape so easily.

Most people will agree with this in principle so far, but it is surprising how few will agree when it comes to putting it into practice. If a farmer is told that by digging up and loosening the surface of his soil in dry weather he is keeping the water in the soil, he may laugh at the idea. When the dry surface soil is broken and the slightly moister soil underneath it is turned over in the process, it looks as though damp soil is being exposed to the air and therefore water is being allowed to escape instead of being kept in. This is probably true, as far as the top 2 or 3 inches of soil are concerned and which, for our purposes, are unimportant. All crops absorb soil-water through the root-hairs situated on their tiny rootlets, most of which are found from 6 inches to several feet down in the soil. Therefore what happens at the surface does not affect them immediately, but it is important that the film water around them should not be allowed to escape through large cracks to the surface, or by capillarity, by the soil being left compact, so that the particles are close together. The breaking of the hard surface soil, not only into lumps but into a fine powder, helps to check this.

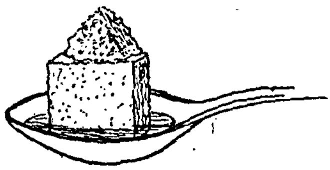


FIG. 7. Experiment with sugar in tea-spoon to show effect of surface mulch.

This principle can probably best be illustrated by a very simple experiment. (Fig. 7.)

Take a lump of sugar and place on top of it a small heap of powdered or granulated sugar. Place the lump of sugar with the loose sugar on top into a spoon and dip it into a cup of tea, or better still, into red or black ink which has been diluted with water. The ink rises rapidly through the lump sugar, thus acting against the force of gravity. This is because of capillary

attraction, the film water surrounding each grain of sugar being passed on to the dry grains which, in this experiment, are above it. The rapid rise of the ink continues until it has reached the top of the lump, when it appears to stop. This stop is only for a short time, however, until the ink is seen travelling more slowly up the little heap of powdered sugar. It passes so much more slowly in the granulated sugar because the particles are loose and farther apart, whereas in the lump sugar they are much more closely compressed. Exactly the same thing takes place in the soil. The upward movement of the soil-water is checked as soon as it comes into contact with the loose soil on the surface, and the deeper the layer of dust, the longer is the water prevented from escaping into the air. As the loose layer gradually settles down, the capillary water passes upwards through it more quickly, so that by breaking it up once more the speed of the escape of the film water is again checked.

Applying this principle to practical agriculture means that in dry weather and in dry climates much of the water in the soil can be retained by frequently breaking up the surface into a fine tilth with a hoe or cultivator. The deeper the surface tilth and the oftener it is renewed, the longer will the water be kept in the soil.

The depth of cultivation practised depends on the depth of the roots. Shallow-rooted plants should therefore not be cultivated too deeply in case the roots are injured. In drier regions where plants send their roots deeper in search of water, deeper cultivation can be carried on than in wetter regions. Nearly all cultivation practised in West Africa is much too shallow, and there is little danger of roots being disturbed by deeper cultivation as long as the present primitive hand-hoes are used.

In countries which were formerly considered to be practically desert, wonderful crops can now be grown without irrigation by the application of these principles of dry cultivation. In parts of Australia, for instance, excellent crops of wheat can be grown where the annual rainfall is only about 10 inches. In Arizona and other Far-Western States in the United States of America, which were once practically desert, maize, wheat, and other crops can be raised successfully even though in some years rain falls scarcely at all, and occasionally it is possible to get only one crop in two years. The solution is in deep cultivation and in the maintenance of a surface dust-mulch. Of course in those countries where ploughs and motor cultivators are used, the

cultivation can be much deeper and more efficient than is at present possible in West Africa. Nevertheless, wonderful results can be achieved even in dry districts by the use of hand-hoes.

If the soil is broken up before the rains set in most of the rain enters the soil and there is much less surface wash due to free water running off the surface. Also rain-water can go two or three times as deep into soil where the surface has been broken first of all. If the surface is hard, the water cannot enter so easily or so deeply. When the rain has ceased the surface should be broken deeply with a hoe as soon as possible. This deep cultivation serves two useful purposes, first to keep in the water already in the soil, and secondly to help the next lot of rain to enter the soil more easily. If careful and deep cultivation takes place after each shower of rain the soil contains much more water than if it is never disturbed. Most striking results can be noticed in this way by any one who lives in a dry country cultivating half his field *continually* in this way and leaving the other half undisturbed. After the rains have ceased cultivation should continue as frequently as possible, say every week, as each cultivation helps to keep the water *in* the soil.

This practice of dry cultivation, as it is called, has revolutionized agriculture in dry regions of the world in the last twenty-five years or so. If African farmers living in such dry regions as Northern Nigeria, the Northern Territories of the Gold Coast, the Sudan, and parts of East and South Africa adopted it, African agriculture in those regions would be greatly improved, and crops grown in regions where it seemed impossible to grow them. Also much heavier crops could be grown by the continual use of the hand-hoe and the continual keeping of a surface mulch.

Another mulch that can be used to help to keep water in the soil in dry weather is known as the 'leaf-mulch'. It is used at present by many African farmers unconsciously, as they weed their crops and leave the dead weeds lying on the surface of the soil between the plants. This is known as a leaf-mulch, and helps to keep water from escaping from the soil and could be more widely used. In a previous chapter it was suggested that dried grass and weeds should not be burned when a farm is being prepared, but should be dug into the soil instead. In practice, however, most farmers still continue to burn their dried weeds. If such farmers, disliking the trouble of burying their weeds, which is the best method, could be persuaded to

leave them lying, it would be a step in the right direction. Such dead weeds left lying on the surface of the soil act as a mulch, and prevent the surface wash of water in the tornado season, as well as helping to prevent loss of water from the soil when dry weather comes. Also the dead leaves gradually decay and form humus on the surface, although not so quickly as if they were buried in the soil. Surface leaf-mulches also help to keep down the growth of weeds, which can easily be kept weeded with a hoe in the usual way, the leaf-mulch being held in the left hand at the same time, and replaced at once together with the dying weeds.

Farmers in certain districts always 'cap' their yam hills with a layer of grass or dead weeds. This cap is really a kind of leaf-mulch and, as will be seen in the chapter on yams, makes a considerable difference to the yield of yams.

Although the leaf-mulch is probably not so effective as the dust-mulch in keeping moisture in the soil, it may be quite effective, and could be used with advantage in any part of West Africa, especially in dry districts.

Best results, however, are obtained when leaf- and dust-mulches are combined, but this means additional trouble, the leaf-mulch being left on the surface of the ground and the dust-mulch being prepared at the times advised. The farmer should lift the dead weeds with one hand, cultivate the soil beneath them deeply with his hoe, and then replace the leaf-mulch on top. This can be done without much additional trouble and the advantages of both methods of mulching can be combined and the water kept in the soil more efficiently still.

CHAPTER IX

FARM IMPLEMENTS AND CULTIVATION OF THE SOIL

THE number and variety of farm implements in use in the twentieth century is very great, but at present most of them are unsuitable for use in Western Tropical Africa, so that only the simplest ones will be described here.

The African Hoe

This is probably the tool most widely used amongst all tribes in West Africa. Its pattern is more or less the same everywhere, with slight modifications in different tribal areas. Usually the handle is short so that the farmer has to stoop constantly in using it. The handle is cut from some strong tree or shrub and generally consists of a side branch with a swelling at one end, into which the iron hoe is fixed. (Fig. 8 *i.*) Sometimes a 'crook' or bent piece, where two branches have joined, is chosen. Some tribes prefer the hoe handle to have such a 'crook', over which the top of the hoe blade is fixed.

Most hoes used by African farmers are made by their own blacksmiths and are simple but strong. Although many European-made hoe blades are for sale in the stores, they have not yet been widely adopted by Africans, who prefer the type of hoe to which they are more used. One end of the blade is sometimes extended into a narrow portion which is thrust through a hole in the top of the handle which has been prepared by boring with hot iron. The blade is fixed into the handle while hot and generally holds well, being forced into the hole still farther by continual use.

In the gravelly soils of Mende districts of Sierra Leone, where rice and ginger are largely grown, a narrow-bladed hoe coming to a blunt point at the end is used. This shape of hoe seems admirably suited for weeding amongst the rice and ginger, which would be injured by a broad-edged blade. The gravelly soil common in such districts would quickly blunt the strongest edge of most hoes, so that the narrow bluntly pointed tool is much more suited for the purpose.

Double-handed Hoes

The majority of hoes in use in West Africa are single-handed and short-handled, the farmer using his left hand to hold the

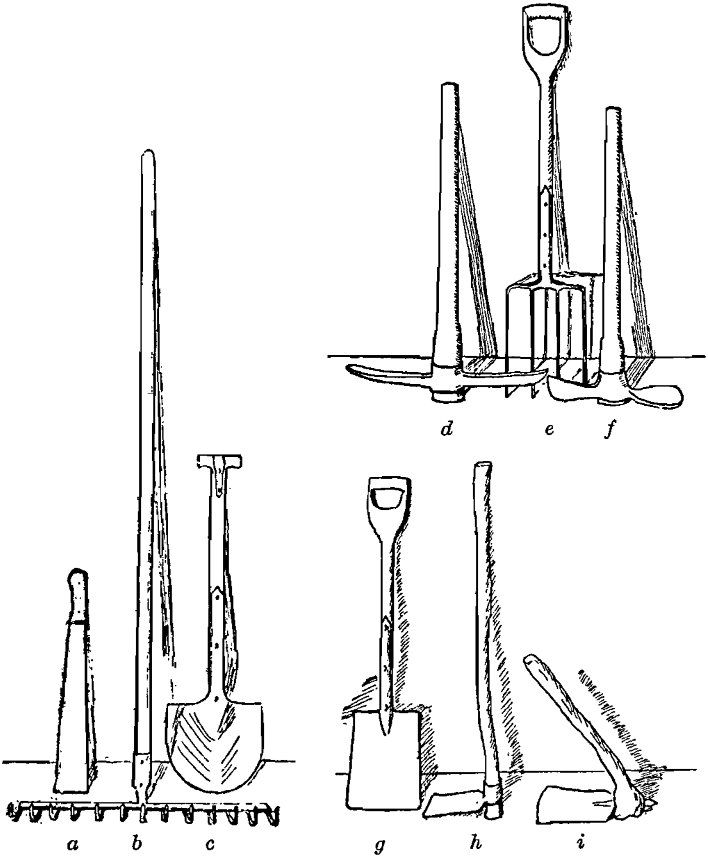


FIG. 8. (*a*) Cutlass. (*b*) Rake. (*c*) Round-nosed shovel. (*d*) Pick. (*e*) Fork. (*f*) Mattock. (*g*) Square-nosed shovel. (*h*) Long-handled hoe (two-handed). (*i*) Ordinary African hoe (short-handled).

weeds which he digs out with the hoe in his right hand. Sometimes when soil is hard or weeds large, he may use both hands for a time. The handle of the double-handed hoe is much longer than that of the single-handed, being 3 to 4 feet, or even longer, so that the farmer can use both hands and still remain practically upright. (Fig. 8 *h*.)

The blade of a double-handed hoe is much larger and broader than that of a single-handed hoe. The blades of such hoes, and even the handles themselves are generally made in Europe and are sold in the stores in some of the larger towns. For some reason they have not yet been adopted by Africans, although in a land where the hoe must play a large part in the immediate future of agricultural methods, the use of a larger and more efficient hoe would greatly increase progress.

These double-handed hoes have several advantages over the smaller African hoes. First, as the handle is so much longer the farmer can stand almost upright. Secondly, being able to use both hands he can put much more strength into his blows, which are thus more effective with little more effort than is necessary for his own primitive hoe. Stones can be removed and large roots can be cut far more easily with a large hoe of this kind. Probably more important still is the fact that with this hoe he can dig much deeper into the soil, and uproot and turn weeds into the soil far more quickly and easily. With a large hoe the farmer can approach more closely to the method of ploughing or turning over the soil used by farmers in more progressive countries. With the small African hoe he stirs only the top 2 or 3 inches of soil, and scarcely turns it over at all, but with the large hoe he can turn the soil over much more thoroughly.

The value of these hoes for future progress in West African farming methods is very great, especially as hoes of this type have been adopted with success by the native populations of British India and elsewhere. They are so simple in structure that they could be made as simply by African blacksmiths as the smaller hoes. Also the African has at his disposal an unlimited number of trees which could be used for the long hoe handles, many of which would be stronger and more lasting than those at present sold in the stores.

Under this heading should come the implement known as the mattock. (Fig. 8*f*.) It has a long handle, but it is double-headed, one side consisting of a short and rather narrow hoe, and the other of a short narrow edge set at right angles to it. This can be used like a small axe and is invaluable in cutting the roots of young trees and shrubs which it is almost impossible to cut with an African hoe, and very difficult to cut with a large double-handed hoe. Having a miniature axe as well as a hoe attached to the head of these implements makes them very useful when

clearing new ground. For that reason mattocks are often supplied by Government and by contractors whose labourers are engaged in clearing new bush. The mattock is a new tool in West Africa; labourers take readily to it, and it is likely that its use will spread amongst Africans. It is invaluable in rough work, but it is not so useful as the double-handed hoe in digging up the soil and in burying weeds.

The pickaxe, which resembles the mattock in some respects, is much more used in road-making and in removing large stones, so that it can hardly be regarded as a cultural implement, although it is sometimes used in school gardens to remove large stones. (Fig. 8 *d.*)

The Cutlass

It is not known for how long this common tool has been in use but it seems likely, from the distinctly African names which it possesses in various vernaculars, and from the method of making it, adopted by so many tribes, that it is a proper African implement. It has probably earned its English name from its similarity to the large knives used by European sailors one or two centuries ago.

The cutlass is a simple and very effective implement in West African agriculture. There are at least two types. One consists of a large, often slightly curved blade and a short wooden handle. This type of cutlass is made by African blacksmiths with a point at the upper end which is heated red hot and then forced into home-made wooden handles which are often wrapped round and bound afterwards with pieces of split rattan palm. Another type of cutlass, however, is now sold in stores, and is being used increasingly by African farmers. The blade is straight and the sharpened edge is slightly longer, while it is almost straight at the end. This type is often used for digging small holes in the soil, for planting seeds, loosening the soil, as well as for cutting. (Fig. 8 *a.*)

The main use of a cutlass is to cut away the bush, especially those thick growths of creepers and shrubs which spring up on old farms from what is known as 'secondary forest'. It is difficult to see how forest farmers could manage without cutlasses. They are used for lopping off branches of trees and shrubs, for cutting the interlacing woody creepers and the yards of long trailing plants which spread like a vast network over old farms. They are also used in cutting the roots of shrubs and young trees, and

even in cutting down the shrubs and trees themselves. The cutlass can be used like an axe, and it is amazing what comparatively large trees and shrubs can be felled by a farmer who is an expert in its use.

It is unlikely that the cutlass will be replaced by any other implement for the forest farmer, for he would be obliged to use a sharp knife of some sort before he could clear the bush sufficiently to use a hoe. In its present form the cutlass seems admirably suited for its main purposes of cutting, but it cannot be regarded as a cultural implement, like the hoe, even though it is sometimes, quite wrongly, used in that way.

The Axe

This tool, which is used chiefly in the felling of large forest trees in clearing heavy bush, is invaluable in agriculture in thick forest districts. The type of axe used is generally two-handed, and many forest people are expert in its use.

The Spade

The European spade, sold in increasing numbers in stores, is still used chiefly on roads, and it is difficult to see how it is to be used in African farming in the near future. (Fig. 8 *g*.) Spades are often seen in use in school gardens, but they are used in such a way as to use up the maximum of human energy with the poorest of results. Most school children hold it wrongly with the blade facing them. They hack at the soil savagely, ruining the edge of the spade, sometimes cutting their naked feet, and often breaking the handle in the process, with very little effect on the soil. The spade must seem a strange and useless implement to most Africans, simply because they have never been taught how to use it. The spade should be used by the foot which is pressed on the top of the blade at either side until the blade is forced deeply into the soil. The latter can then be lifted and turned over to a depth of several inches. This is difficult for most Africans who do not wear shoes, as it would hurt their feet. If Africans could wear rubber or leather sandals or shoes, and use the spade in the proper way, they would be amazed at the results they could get with it. Not only can the spade penetrate much deeper than single or double-handed hoes, but it is much more effective in burying weeds and in turning over the soil deeply.

The spade, however, is a European implement and can be seen at its best in use in a country like England where the soil is deep and rich and kept constantly moist by the continual light rainfall. Under such conditions it can be used with good results and without a great deal of effort. In tropical Africa, however, where the soil is often not so deep and may contain more gravel and stones, the spade is often more difficult to use. In many parts the soil is hard at the end of the dry season, when farmers generally prepare the soil, and is so hard in some districts that it needs great effort to drive the spade in far enough with the foot to get the best results. Where the soil is deep, loamy, and moist, but not too wet, the spade could be used with good effect in small gardens, but it is unlikely that it will be used on large African farms. For general purposes, especially where the hardened soil is being dug at the beginning of the rains, or in the tornado season, the double-handed hoe or the mattock could more profitably be used.

The shovel, which resembles the spade in many respects, except that the blade is broader and slightly concave and either square or round nosed, is often wrongly used in school gardens in the way described for the misuse of the spade. (Fig. 8 *c*.) The shovel should *never* be used for digging purposes as numbers of shovel blades and handles are broken in this way. It is doubtful whether the shovel should be used in school gardens at all, except for making garden-paths or for levelling purposes, when the loose soil has to be shovelled up and thrown from high spots to low places, or in filling loose soils or stones into barrows.

The Fork

The large fork is a European implement somewhat like a spade, except that instead of a broad flat blade, there are generally four stout prongs or teeth. There are two types of forks, the manure fork and the digging fork. The manure fork is used in Europe chiefly for handling farmyard manure, which contains much straw, and its teeth are longer and rounder than those of the digging fork. (Fig. 8 *e*.) The digging fork has shorter and larger teeth which are flattened and are bluntly pointed at the end. It is used for digging, or rather loosening the soil and can be used for this latter purpose in gardens in West Africa, for penetrating rather hard soil, or sticky clay soils. It is not, however, so useful in the tropics as in the temperate zone.

The hand fork is a small hand tool with a short wooden

handle and several short teeth—4 to 6 inches long. It is an imported tool and is useful in forking the soil round seedlings, or where space is limited, as in boxes and flats.

The Rake

This implement, which is also of European origin, is used chiefly in school gardens. (Fig. 8 *b*.) It is often wrongly used by people who try to dig up the surface soil with it by jerking it, teeth downwards, on to the soil. The long handles are often broken in this way, and the rake must never be used for digging or even for loosening the surface soil. The soil should always be loosened first with hoes, and the larger lumps broken with the back of the hoe. The rake can be used in levelling off the surface of the soil when it has first been levelled as far as possible by the hoe, and also for breaking up the smaller lumps and leaving a fine tilth or dust-mulch on the surface.

The other main purpose of the rake is for raking up dead leaves and weeds from the school garden paths, or elsewhere, leaving the garden clean and tidy.

Farm implements drawn by other than man-power

So far all the tools we have dealt with are hand implements, but much heavier work can be done if larger tools are used, as they are in other countries. In the United States and Canada, and to an increasing extent in England and elsewhere, larger implements are being drawn by motor-tractors or by a pair of steam-engines hauling giant implements to and fro between them by a steel cable. While modern farming is more dependent upon the tractor, which has been tried in one or two parts of West Africa, it is not likely that this implement will be used much in West African agriculture in the near future. The tractor is a symbol of the capitalist and plantation method of agriculture, whereas African farming is almost entirely of the small-holding or peasant type, and is likely to remain so as long as the present tribal system of land ownership and the prosperity of the small farmer continues. While it is true that tractors could be bought by agricultural co-operative societies in West Africa, there are many problems which would make its use in the forest country almost impossible at present. Secondly, most of West Africa is quite unsuitable for the use of tractors, without very expensive clearing of the bush and 'stumping' or digging up of the roots which are larger and more numerous than in most

other parts of the world. Naturally it would be easier to begin on level areas covered with grass, where the soil is deep and the trees and shrubs comparatively few. Parts of Northern Nigeria, the Northern Territories, and the coastal plains of the Gold Coast, would be most suitable.

When the problem of using animal power for drawing farm implements is investigated, the same objections can be raised but to a less extent. The same problem of clearing the bush and digging out all the roots arises, but in those districts where there are not too many large roots this can be attempted. There is always the difficulty of removing large stones and the termite and ant-hills, which are generally exceedingly hard in the dry season.

It is doubtful whether it would be worth while to clear out all roots and stones and ant-hills in those districts in closed forest country, partly because of the enormous expense, and the ever present problem of tsetse-flies. These flies, as every one now knows, are the carriers of a deadly disease known as sleeping sickness, which they are able to impart to man as well as to animals. They live and shelter in densely shaded districts, in closed forest, and along the shady banks of rivers in otherwise open districts. Practically the only parts which are free of them are the open grassy coastal plains and some of the more open parts of the country to the north of the thick West African forest. Even there they are sometimes carried by trains or motor-lorries, although they do not usually breed in such districts. In the rainy season the tsetse-fly goes farther into the open country, favoured by the rapid growth of vegetation, retreating once more to shadier places when the dry season and the grass fires come.

The tsetse-fly makes it impossible for horses or ponies to live except in the most restricted parts of West Africa, and even there their life is short. Consequently the use of horses or ponies on West African farms is almost impossible, although the sturdy mule seems better able to endure the heat and the hard work and the ravages of tsetse.

This leaves oxen, which are used in India and other parts of the tropics and sub-tropics for ploughing and other farm purposes. Oxen have been used by the most primitive farmers in India for generations. They are not used in West Africa, first, because it is predominantly a forest country, and secondly because the idea of using a plough is quite new. Again, there is

the difficulty of the tsetse-fly. The humped-back or zebu cattle of Northern Nigeria and the Northern Territories of the Gold Coast are closely related to the humped cattle used in farming practice in Egypt and the East. These cattle have been trained and used in the Northern Territories of the Gold Coast, in Northern Nigeria, and also in parts of French West Africa, but their use has mainly been introduced by Europeans, so that it is still in the experimental stage. These experiments have been largely successful, so that there is every reason to expect that oxen will be used with success in the future in these drier districts. These humped cattle are fairly docile and could easily be used by Africans on a large scale, an untrained animal being yoked with a trained one until the younger animal becomes used to its new activities. These humped cattle, however, readily succumb to the attacks of tsetse-flies, so that they cannot be used except in the most open parts. Near tree-lined rivers or in other shady places, and especially in the thick forest, it is quite impossible to use them.

But there is another breed of cattle, known officially as the 'West African Shorthorn', which might be used instead in these sleeping-sickness areas. This is the small level-backed coastal breed which is generally black and white, and sometimes red and white, and like small European cattle in general appearance. These cattle are kept along the coastal plains of the Gold Coast, and other cattle, which appear to be the same breed, are found in thick forest regions in many parts of Southern Nigeria, notably between Akure and Benin, where they occur in almost every village and feed along the roadsides. It is believed that this breed is practically immune to the attacks of tsetses and they appear to be much hardier than the Northern zebu or humped type. These cattle have been successfully used to a small extent for farm purposes on the Achimota farm and also at Tamale, and it is quite possible that they could be used all along the coastal plains of the Gold Coast, and in parts of forest country in West Africa as well. (Plate II *b*.)

The Plough

This is the main type of implement which could be used with great advantage to West African farming if horses or oxen were used. For fuller details of various types of ploughs the student is referred to fuller text-books on European agriculture. The plough recommended for use in West Africa is one of the Indian

type of ploughs (made in England) which is small and can be pulled by two oxen. (Plate II *b*.) These ploughs which closely resemble the one-mule plough of the negro farmer of the southern parts of the United States are quite cheap and very simple in structure. They consist of a beam, preferably made of iron, to which a steel 'mould-board' is attached. This is the part of the plough which turns over the soil and weeds and buries them, after the weeds have been cut by the knife or disk coulter, which is situated on the beam in front of the mould-board. If these ploughs were used in West African farming, the present practices could be greatly improved, the present method of burning grass and weeds could be prevented, and the soil greatly improved by turning all this humus into the soil. These Indian peasant ploughs are so simple in structure that they have been copied by blacksmiths all over India and are used there increasingly every year.

The Harrow

This implement consists of several iron bars joined together to form a square or rhombus, with several cross iron beams in both directions. At intervals and on the lower surface of these iron bars strong iron teeth several inches long are inserted. The harrow is made in different weights according to the type of work to be done, the lighter spike harrows being used on a farm in the same way as a hand rake is used in the garden. The heavy-weight spike harrows are used more as cultivators. The harrow can be pulled by oxen, and as the teeth are pulled through the soil, they help to break up the lumps and level off the surface. They also collect roots and other rubbish which will quickly clog the teeth unless the harrow is lifted every few yards to release them.

The harrow is generally used after the plough, and serves to level off and break up the soil in preparation for the planting of the seed. Soil loosened and levelled in this way is in the best possible condition for the early rains to enter it and penetrate deeply. (Fig. 9.)

Quite another type of harrow is the chain-harrow, which is used mainly to collect and roll up rubbish from the surface of the fields or to distribute dung evenly over them.

The Horse Hoe or Cultivator

This is the last type of ox-drawn implement suggested for use on small African farms, and, like the plough and the harrow, is

of simple structure. The 'horse hoe' is the English name for this implement, just as the cultivator is its American name. The best type is that known in the United States as the

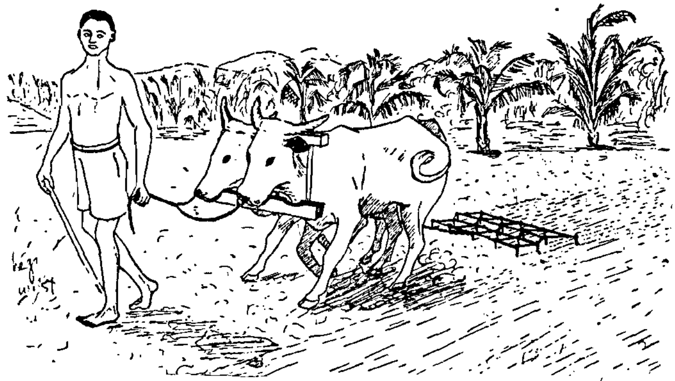


FIG. 9. Harrowing with oxen.

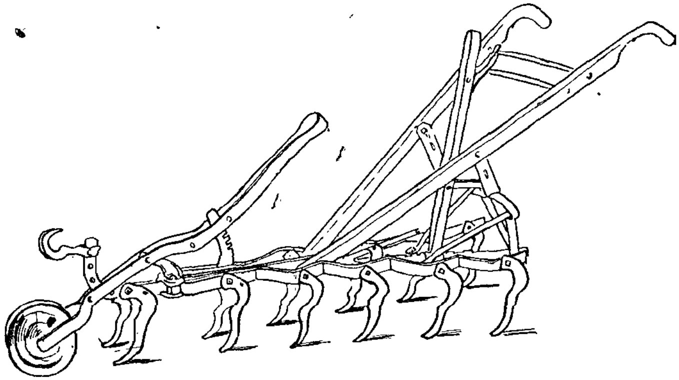


FIG. 10. Twelve-tooth cultivator.

twelve-tooth cultivator. It consists of two iron beams joined together at the front and forming a V, which is pivoted in front and can be closed, or opened more widely by the use of a vertical lever. (Fig. 10.) Along each beam are six iron teeth like those of the harrow. This cultivator is really like a modified harrow,

and can be pulled down between the rows of corn or other farm crops. When the rows are close together the two beams can be brought close together by means of the lever, and when the crops are wide apart between the rows the two beams can be opened, so that the teeth cover practically twice the distance.

This cultivator is simply made and quite inexpensive and it is not difficult for one ox to pull it. Its main purpose is to go down between rows of crops, pulling out weeds by the roots, and breaking up the surface soil. Such cultivators are invaluable in forming a dust-mulch in dry districts, and should be used after every downfall of rain before the surface of the soil becomes hard and cracked. They can cover more ground in a day than six or ten men, and only need one, or perhaps two men to operate them, one to direct the cultivator, and one to lead the ox when the animal is not used to farm work.

When a farmer does not want to go to the expense of buying such a cultivator, which is, however, quite cheap and well worth the money spent on it, he can easily make a home-made cultivator in the following way. Three strong pieces of wood are fixed together in the form of a triangle with the short piece at the back and the two longer pieces at the sides and the point in front. Into the lower surfaces of these pieces of wood long iron-pointed teeth, 4 to 6 inches or more in length, can be driven or fixed, with the pointed ends towards the soil. These home-made cultivators can be made any width, and should be made of the same width as the average distance between the rows of crops. They are quite effective in practice and are almost as good as the imported twelve-tooth cultivator, except that they are slightly bulkier, and cannot be opened or closed, but remain of a fixed width.

The value of using farm implements to cultivate the soil has been dealt with in the last chapter. One of the main advantages, however, of ploughing the soil, besides burying the surface weeds and thus forming humus, is to bring the layers of soil below the surface to the top, where they are acted upon by the sun and air. These help to break up the plant foods in the soil, so that the more soil is turned over, the more fertile and easy to work it becomes.

Clay soils, as we have seen, are made more friable and less sticky when they are kept stirred and exposed to the heat of the sun and the action of the air. Ploughing, harrowing, and culti-

vating also help air to penetrate beneath the surface as well and reach the roots of growing crops, and to break up into simpler and more soluble form the plant foods present in the soil.

The action of the cultivator in forming and maintaining the dust-mulch has been mentioned, and the value of the dust-mulch in dry districts has already been fully dealt with in the last chapter.

CHAPTER X

MAIZE OR CORN (ZEA MAYS)

THE maize or corn plant is of American origin, but it is now widely grown in the tropics and sub-tropics and is one of the main food plants of West Africa.

In the United States, where the growing of corn is most fully developed, there are numerous varieties recognized, and several distinct types, such as pod corn, pop corn, sugar or sweet corn, flint corn, and dent corn. Pod corn has each seed enclosed in a separate little pod, while pop corn, which has small seeds, is used for 'popping' in front of the fire.

Sugar or sweet corn, as its name implies, is a type of which the grains are particularly sweet. As the cobs are developing, and the grains are 'in milk', that is, full of sap, or almost fully formed, the cobs are picked and the grains are often eaten raw, as at this stage they are very sweet. More often such sweet corn is boiled on the cob almost at once and eaten with butter spread over it. In parts of the United States the grains in this state are specially cooked and tinned and there is a considerable industry in tinned sweet or sugar corn. Tinned sweet corn does not taste as sweet as fresh sweet corn, mainly because sweet corn quickly loses much of its sweetness after being picked, and if it is not cooked within twenty-four or thirty-six hours, much of its sugar content has disappeared.

Flint corn is a type of corn in which the grains are hard and horny in appearance. They are sometimes somewhat wrinkled and when broken across they look like a broken piece of flint.

Dent corn, which is the commonest type and forms the major part of the corn grown in the United States, is distinguished by the dents in the outer ends of the grains. The cobs of dent corn are generally large, and the grains themselves are very large. It is the type mainly used for the manufacture of corn meal and other corn products in the United States.

Some of these American types of corn correspond to some of those already grown in West Africa, and the uses of each American type show along what lines the types of corn already grown in West Africa could be developed.

There are several varieties of corn occurring in West Africa, the main differences being minor ones, such as the colour of the grain, which is generally yellow, white, or reddish. Short season

'white' maize has become increasingly popular among Yoruba farmers in recent years.

Maize is a crop which will grow in almost any part of West Africa. In the tropics it will thrive from sea-level up to a height of 4,000 or 5,000 feet, and will grow in most soils, except pure sand or clay. It requires a rainfall of 30 inches or more, and, although it can be successfully grown in America, South Africa, and elsewhere with a rainfall of 20 inches and even less, it could only be grown in West Africa in regions of such low rainfall when farmers prepare their soil deeply, cultivate it after every fall of rain, and carry out the main principles of dry farming as practised in America and South Africa. Similarly when the rainfall is heavy, for example 100–200 inches or more, corn does not really thrive. It does best in regions of 30–60 inches of rainfall, in sandy loam or loamy soils, rich in humus.

It is a sun-loving plant and will not thrive so well under shade. It is a somewhat exhausting crop and responds well to manuring, particularly when quick-acting nitrogenous manures are used, as they quickly show their effect in increased leaf-growth.

The soil should be cleared and dug as deeply as possible before the maize is planted. The seed is planted after the first rains have fallen, generally in rows 3 to 4 feet apart. The seeds may be sown either in 'hills' or on the flat at distances of 3 feet apart in rows, three seeds to a hole, or one or two seeds in holes 15 to 18 inches apart in the rows. The former is the better system, and only carefully stored seed from specially selected high-yielding plants should be sown if the heaviest yield is to be expected.

The seed generally germinates quickly, and during its early growth care should be taken to keep it free from weeds. It is most important to keep the ground well stirred and cultivated, especially in drier regions after rain has fallen, as this helps to conserve the moisture in the soil for the benefit of the crop. When the plants are about 1 foot high, the superfluous seedlings can be pulled out, leaving only one or two plants every 3 feet, or one plant every 15 to 18 inches, according to which of the two systems of planting is adopted. The advantage of reducing the number of plants is that one or two plants per 'hill' can absorb food from the soil better than three or four, and yield larger and better cobs than where the plants are allowed to remain too crowded. In West Africa the general custom is to

leave *all* the plants in the hill, but this is to be condemned for the above reasons.

Corn takes from three to four months after planting to reach maturity, some varieties yielding seed within ten or twelve weeks. If the cobs are pulled when they are 'green' and the seeds are still full of a milky sap, they can be cooked and eaten in the same way as American sweet corn, although they do not contain the same percentage of sugar.

As the plants approach maturity, tiny flowers appear on special flower-stalks at the top of the plants. These are known as the 'tassels' because of their shape. They bear the male flowers, as can be seen when the ripe tassels are shaken and clouds of pollen dust comes from them. In the axils of the leaves special leaf-like sheaths are formed, enclosing the developing seeds. From the end of these sheaths, known generally as the 'shucks', delicate silky threads hang down. These are generally known as the 'silks', and are the stigmas of the female corn flowers. Each stigma or 'silk' is joined to a corn grain on the developing cob enclosed by the shucks. As the female part matures the silks become sticky, so that pollen falling from the tassels is caught on them, the pollen tubes grow down to the ovules or developing grains, which are then fertilized, and the grains grow to their full development. The tassels of a corn plant are generally mature before the silks, so that cross pollination takes place, although the pollen from one plant can, and sometimes does, fall on the silks of the same plant, fertilizing the ovules. The seed from self-pollinated plants, however, is not generally so good or virile as that from cross-pollinated plants.

When the silks have dried up thoroughly and the leaves and shucks are turning yellow it is a sign that the corn is ripe and ready for picking. The shucks are wrenched off with a twisting motion of the hand and are often dried in the sun before storing.

In many parts of West Africa two crops of corn are raised during the year. In those regions of two distinct rainy seasons, that is with main rains from April to July, and 'small' rains from September to November, this is generally possible. Such regions are mainly in the closed forest country, but in the coastal plains, for example in the Accra and Cape Coast districts of the Gold Coast, the 'small' rains cannot always be relied upon, so that in dry years the second corn crop is generally a failure. The corn produced in main rains is generally softer in

texture and easier to pound. In many parts of West Africa corn is grown in damp situations beside streams during almost every month of the year.

In West Africa many tribes store corn in the cob. The dried cobs are stored in special stacks varying in size, but more or less uniform in shape. The shucks are placed round the edge of the stack in a circle with their lower ends outwards, and the centre portion is filled with the remainder. The cobs are placed in this way, layer upon layer, until as the top of the stack is approached the circles become smaller and smaller, finishing in a point. These stacks are often thatched over with grass to keep out rain, and the corn is stored in this state sometimes for several months. The stack is often made on a raised platform of sticks or stones to keep the corn at the bottom of the stack dry. Corn stored in this way and in the 'shuck' seems to keep better and to be less attacked by weevils than when it is stored in the cob only or with the grains shelled first. The cobs are therefore removed when required, the shucks are taken off and the grain removed either by rubbing the cobs against each other or by removing them with the fingers. (Plate III *a*.)

Another African system of corn storage is to place the cobs, either with or without the enclosing shucks, in specially constructed 'barns' in the compounds. These barns are several feet in height. They are thatched over, and are supported on four corner posts. The floor of the barn is often made of pieces of the rachis of the Oil or Raphia Palm, generally known as 'palm branches', and is 3 feet or more above the ground, and has spaces of ½-inch or more left between each palm 'branch'. The walls are made in the same way. A fire is generally lit under such barns and the smoke helps to keep away weevils and other pests and dries the cobs at the same time. Probably the creosote and other substances in the smoke act as a disinfectant and prevent the spreading of moulds and other fungus diseases amongst the stored grain.

Weevils are the chief pest causing damage to stored corn. They are small beetles with pointed 'snouts', and they bore into the grain, generally into the embryos, eating the stored starch and other food as they go, ruining much of the seed for planting purposes, and considerably reducing its value as food. As already stated, weevils seem to attack the grain less when it is stored in the shuck. If the shucks are removed and the grain taken off the cob and then stored, there seems to be more

danger of weevil attack, unless special precautions are taken to prevent it.

When the grain is first shelled, diseased or weevil-attacked grains can be detected and removed, and the grain should then be stored in special 'bins' or air-tight metal receptacles. (For further details on Corn Storage, see chapter on 'The Storage and Testing of Seeds'.)

Corn is attacked by various insect pests and plant diseases, details of which can be found in more advanced books, where the methods of prevention and control are given. On the whole the corn plant in West Africa is fairly free from pests and diseases compared with that in other parts of the world. Only one disease, corn smut, will be dealt with here. (Plate III *b*.) This disease, well known in America and other corn-growing countries, has recently made its appearance in West Africa, so that it is not out of place to mention it in the hope that measures will be taken to control it. Smut is first distinguished on a corn plant by a swelling and malformation of the flowers, either in the tassels or the 'ears'. These swellings, which are white in colour, finally burst, and a black powdery substance, the 'smut' or spores of the disease, comes out, and is rapidly spread by the wind to other corn plants and other corn districts. These spores can remain dormant for a considerable time and attack other maize plants as soon as they find themselves in the right conditions for doing so. Where the tassels are attacked, they first of all give rise to female organs (corns) which become attacked by the disease in the same way as described for the attacked ears.

The usual custom of planting two corn crops in one season helps in the rapid spread of the disease. The presence of smut in corn used for human food gives it an objectionable taste, whereas when eaten in any quantity by cattle it acts as a poison.

The methods of prevention or control of the disease in West Africa are as follows. No grain from an infected source should be planted, or the disease will appear in the next generation. Maize should not be planted too closely, as this assists the rapid spread of the disease. The practice of growing two crops of maize in one year should be abandoned once the disease makes its appearance, and preferably before this happens. Also proper rotation should be followed, and no more maize should be sown on the same piece of land for at least three years. As soon as the disease makes its appearance, the infected plants should be pulled up and burnt at once *before the tumours burst*, as other-

wise the disease will be able to spread. When a farm has been infected, all the stems and trash remaining after the harvest should be burnt. No animals should be allowed to eat uncooked smutted corn, as the spores can pass unharmed through the digestive tracts of animals.

In those countries where corn smut has been a pest for many years, attempts are being made to produce a strain of corn that is resistant to the disease.

Besides the use of 'green' corn as food in West Africa as a local equivalent of 'sweet corn' the corn plant has other and more important uses. The young stems can be cut green and fed to animals, particularly cattle, and they are sometimes grown for this purpose, mixed with velvet beans. The green stems and leaves of corn are used in America and elsewhere either in the green state or as silage for cattle and other live stock.

After their removal from the cobs the dried shucks can be used in the making of home-made door-mats. They are also used by market women, who use them for wrapping up certain foods such as corn 'kenki' before they sell them in the markets.

It is for the dried grains, however, that corn is mainly grown in West Africa. Many villages have their own corn-mills in which simple petrol engines attached to small grinding-mills are used. The farmer or corn dealer sends his or her corn to these mills, where it is ground up into a coarse powder, after which it is made into various corn foods.

In corn-mills the state of fineness to which the corn is ground can be adjusted. For cornflour it is adjusted so that the corn is ground up very finely. For the making of corn meal the maize is first dried thoroughly, then ground up, passed through a screen, and the coarser particles passed through the mill again.

Sometimes the grain is broken with a pestle in a mortar. The first stage in the pounding, where each grain is broken into several portions, is known as 'cracked corn' and is suitable mainly for feeding to poultry, being much more economical to use than whole grains. The Hausa women are expert in the grinding of corn in mortars, and use a specially shaped mortar and pestle for the purpose, by means of which they produce a very fine white flour which is made later into various corn foods.

In the making of such African dishes as 'kenki' the moistened corn is ground on a large flat stone with a smaller stone.

One of the main commercial uses of corn is the making of

cornflour. Cornflour, which is a fine white powder, is used in the making of cornflour puddings, corn bread, and many other foods, including such special breakfast dishes as 'Grape-nuts', 'Force', and others.

Corn is also used in America and elsewhere for the manufacture of corn starch, and alcohol can also be manufactured commercially from the grain.

The embryo of the corn seed, sometimes known as the 'germ', contains about 30 per cent. of oil, which is extracted and used in America as a salad oil or for paint. The remainder of the corn grain, known as the endosperm, is the portion which consists almost entirely of starch.

West African maize could be, and has been, used on a small scale for export, but many of the seeds were full of weevils when they arrived in Europe. Also West African maize is not of such good quality as American or European maize. The chief methods of improving the size of the cobs and the yield is either by careful seed selection from specially high-yielding African plants, or by hybridization. Hybridization, or 'cross-breeding' to use a simple term, has been carried out in Nigeria, for example, where at Ilorin in 1913, the American variety 'Hickory King' was crossed with a good local variety. The introduction of improved American varieties such as 'Hickory King' and others has been carried out several times, but they rapidly deteriorate in West Africa, owing to cross-breeding, and soon almost all trace of them is lost, as they rapidly merge into the inferior West African varieties. Only by careful selection or careful hybridization, kept up by Agricultural Departments, or by special plant breeders, year after year, could strains of improved corn be maintained in West Africa.

CHAPTER XI

RICE (ORYZA SATIVA)

RICE, which is probably the most important cereal grain in the world, is an annual plant with pale green leaves like those of grass, to which family rice belongs. There are many varieties of rice which vary in height from 1 to 6 feet, and mature generally four to six months after sowing. The flowers are produced on a flower-stalk and are green and inconspicuous, and are followed by the fruits, which are oval in shape, pointed at each end, and covered with a strong seed-coat or 'husk'.

There are two main types of rice, swamp rice and upland or mountain rice, which are so different in their soil and climatic needs, as well as in their method of cultivation, that they will be dealt with separately here. The term 'upland rice', however, is somewhat deceptive as it really produces heavier yields when grown on damper soils, or with heavier rainfall than in those districts where it is usually planted. It is true that it differs from swamp rice in the amount of water it requires, as real swamp rice does best when growing almost constantly submerged.

SWAMP RICE

This type, as its name implies, is grown in swamps or marshy places, especially along river-banks. It is grown in several parts of West Africa. In Sierra Leone it is grown in the deep muddy soil along the mangrove swamps, particularly in the Scarcies district, and also along the banks of rivers. On the Gold Coast swamp rice is mainly grown in fresh-water swamps of the Nzima district in the Western Province, and in other parts of the Colony it is sometimes grown in comparatively small areas in marshy places. In Nigeria it is grown in the Kontagora, Yola, Nupe, Zaria, and Kano districts, as well as in other parts of Northern Nigeria, where it is cultivated in low-lying marshes and near streams. Dalziel suggests that it could be grown to a far greater extent along the banks of the Benue River. In Southern Nigeria its cultivation is also limited to swamps. In no parts of West Africa is swamp rice specially irrigated, as it is in many parts of the great rice-growing countries of the East. The only irrigation done is natural irrigation, when the low-lying land in valleys becomes flooded in the rainy season and gradually dries off again after the rains have ceased. The Temne and Mende

farmers' methods of growing swamp rice will be chosen as an example, as they are famous for their rice farming, and other West African tribes have much to learn from them.

Much swamp rice is grown in the Great and Little Scarcies and Port Lokko regions of Sierra Leone. The Scarcies rivers and the neighbouring rivers are slow flowing, and along their lower portions they are surrounded by swamps. As the fall to the sea-level is very small, these rivers are tidal for considerable distances from their mouths. The salt sea water, mixing with the fresh river water causes the water to be brackish, that is half salt and half fresh, and under these conditions mangrove trees thrive, forming a dense tangle of stems and aerial roots which help to hold the mud. These mangrove swamps, therefore, contain rich alluvial soil which is further enriched by the mass of leaves and other decaying swamp vegetation which adds abundant humus. But although these mangrove-swamp soils are amongst the deepest and richest in West Africa, they have three main disadvantages from an agricultural point of view. Firstly, they are waterlogged for part or for the whole of the year, and most plants cannot grow without air in the soil. Secondly, they are covered with a dense tangle of mangroves which are not only difficult and expensive to clear, but also dangerous, as the wood splinters so easily. Thirdly, they contain varying amounts of salts, mainly common salt (sodium chloride) which, although useful to plants in small quantities, is generally fatal in large quantities.

Swamp rice is the crop most suited to these tempting though difficult conditions, but only in 1885 was the first attempt to grow rice in these mangrove swamps made in Sierra Leone, where the Temnes introduced the transplanting method from French Guinea. Rice culture spread rapidly in these swampy regions, until now most of the swamp land suitable for growing rice is in use.

So great has the competition for suitable rice-land become in such districts that a considerable rent has now to be paid by would-be farmers, so that about one-half of the rice grown there is grown by tenant farmers.

Many parts of mangrove swamps, such as those portions nearest to the sea, are much too salty for the growing of rice, unless they are properly drained first. In other parts where the soil is not quite so saline, special salt-resisting varieties could be tried out and new areas of swamp brought under cultivation.

In such districts the water is practically fresh in the rainy season, so that if a quick-growing variety were grown, crops of rice could be obtained. Other regions, higher up from the mouth of the river, are much less salty, and it is in these regions that most rice is grown. Beyond them are regions which are only invaded by salt water at particularly high tides and at spring tides. Rice can also be grown there.

Special gangs of men are usually employed for felling the mangroves and clearing the ground for rice growing, and the felled timber is used for dyeing, as firewood, and for other domestic purposes. After felling, the trees are allowed to rot for three years, after which the rotted wood is piled into heaps and burned, when this is possible. The subsequent work of clearing and preparing the soil in later years is comparatively simple, as only short matted grasses need to be cleared. These are dug up by the roots, piled, and burned. Such soils, when cleared, are very rich indeed and can produce many crops of rice without apparent exhaustion. Each flooding of the river brings fresh mud or alluvial soil to enrich the land.

Besides the rice farms in the mangrove swamps, swamp rice is also grown in the fresh-water swamps beside rivers. In some parts the flooding is too deep to allow ordinary kinds of rice to be grown. Under these conditions the introduction of specially tall-growing varieties would ensure that these swamps could also be used for rice growing.

Swamp rice is not sown broadcast in these regions as it was found that some of the grain was carried away by currents of water, so that the transplanting system has been adopted instead.

The rice for the mangrove swamps in Sierra Leone is first grown during May and June in special nurseries which are generally made on rather sandy soil away from the swamps, the seed being sown broadcast and fairly close, after the land has been cleared and the weeds burnt. After six to eight weeks, when the time comes for transplanting, they are dug up and the upper portions of their stems and leaves are cut with a sharp knife, this process being known as 'trimming'. The seedlings are tied into bundles and transferred to the rice-fields by boats, and are then transplanted by a forked transplanting implement, about 9 inches long and with a blunt V-shaped notch at the lower end. It is made of either wood or iron. Three to five seedlings are planted in a hole and the holes vary from 6 to 12

inches apart, depending on the richness of the soil. The young plants will keep as long as one week or more before dying, and the trimming serves the double purpose of preventing too great a loss of water from their leaves during their transporting and subsequent planting, as well as preventing the young plants from being flattened by heavy rains after transplanting. The transplanting is done in July and August, the land having been cleared of weeds in the previous dry season (March–April).

The rice-fields remain flooded during the rainy season, from June or July until October, the floods being at their greatest in September, when they frequently cause serious damage to the crop. During these months, however, the flood water is fresh all the time, but as the rains cease the influence of the salty tidal water is gradually felt, until in January or February or later the brackish water kills the rice plants in certain districts.

The main harvesting takes place in December, men, women, and children helping. (Plate IV.) The heads are cut off about 6 inches from the top, women and children cutting off the heads one by one, and then tying them into a bundle when one handful has been collected. This is a slow and laborious method, but the men gather ten to twenty heads together and cut them at one time with a larger knife. These are then tied into small bundles and thrown on the stubble to dry for two or three days, after which they are stacked in the highest point of the rice-field, above high-water mark. If a town is near the stacks are made in the owner's compound, these stacks always being circular in cross-section, up to 6 feet in diameter at the base and up to 8 feet in diameter at 5 feet from the ground, after which they taper to a point eight feet in height. These stacks are sometimes thatched with grass or rice-stalks, or covered with nets to keep away the birds.

The same main principles of rice cultivation are carried on in the fresh-water swamps along rivers as in the mangrove areas. The time of planting and transplanting varies somewhat according to the region and to the time of the highest floods.

In both fresh-water and mangrove swamp rice regions, a certain amount of rice continues to ripen in the low-lying damp parts of the rice-fields in the dry weather. This is called the 'after crop' and continues to ripen until as late as March or April, so that this crop is harvested gradually every morning by women and children. All 'after crop' rice is used for immediate consumption, while part of the main crop is stored.

In some regions a system of double cropping is practised. The first crop is sown direct without transplanting in May or June and is harvested in October and November, and a second crop which has been previously raised in nurseries in September and October is transplanted in November. This second crop is generally a quick-maturing upland variety and can come to maturity without flooding, being harvested in February or March. A second crop can only be raised in those districts where the soil is damp even for part of the dry season, and where there is not an excess of salt.

Swamp rice is grown in the Apollonian district of the Gold Coast where it is the main crop in many parts. The Nzima farmers clear and burn the bush and prepare the land, after which the seed is sown *broadcast* at the beginning of the rains, in April, and the seed is roughly covered with a hoe. The fields are then surrounded by short fences to resist the attacks of the large edible African ground-rat which causes so much damage by eating the stems. At the end of April and in May and June the rivers and streams flood the rice-fields and the rice receives practically no more attention until it is ready to harvest at the end of August. Although swamp rice grows well when flooded it does not thrive in regions that are permanently flooded, but does much better when it is flooded periodically. The method of harvesting is to cut one head at a time and dry them before stacking, which is generally done in the temporary shelters in the fields.

Preliminary attempts have been made to grow superior varieties of imported rice. These varieties are better than local varieties in that they are heavier yielders and also do not shed their grain so easily during the period of harvest. Imported varieties, however, are not so hardy or adaptable as local varieties, especially with regard to depth of water required. Imported varieties thrive when the depth of water is kept regulated, but in West Africa where the irrigation of rice consists of natural flooding and the depth of water is very variable the local varieties are much better suited to sudden changes in the depth of the water.

Much more satisfactory crops of swamp rice could be grown in West Africa if the method of cultivation adopted in the great rice-growing countries of the East was followed. Such improvements should consist mainly in greater care being given to controlled irrigation whereby the rice-fields can be periodically

flooded to a required and constant depth, and by more attention to puddling and transplanting, as well as to the growth of improved and heavier yielding varieties.

DRY-ZONE or UPLAND RICE

This type of rice is quite different in its requirements both as regards soil and climate. It can be grown on lighter or more open soil and can grow without the land being flooded. Naturally it does best where the soil holds the water well, and in low-lying districts of Northern Nigeria large quantities of this kind are grown. Nevertheless, perfectly good crops can be grown in quite open country of the Savannah Forest type, where there is a rainfall of between 30 to 50 inches and where the undergrowth of the forest is naturally grass. Under these conditions considerable areas of dry-zone rice are grown in the Kpandu district of British Togoland, whereas in the neighbouring Akpafu district rice is grown on the steep stony slopes of the hills and forms the main food of the people throughout the year. Dry-zone rice is also grown in many parts of Northern Nigeria, in the Northern Territories of the Gold Coast, particularly by the Dagomba people, and also in parts of Sierra Leone.

The ground is cleared first, the bush and weeds are burnt, and the ground is then dug up and the seeds are sown broadcast over the surface, and although it will grow in this way, many farmers cover the seed over with soil afterwards. Broadcasting seed is nearly always a wasteful method, and the best results are generally obtained when the seed is planted in rows. These rows should be 3 feet apart and the plants should be 4 or 6 inches apart in the rows. The seed is generally sown during the early rains, that is after the beginning of the main rains in May or June, so that the rice germinates quickly and becomes established.

The Mendes of Sierra Leone, who are expert growers of dry-zone rice as well as swamp rice, keep their farms free of weeds in the growing season by pulling the weeds up by the roots and throwing them on the tops of the stumps of trees or shrubs cut down in preparing the farm. In this way the weeds rot and can then be added to the soil later as compost. The Mendes practise inter-cropping amongst their rice, but to a smaller extent than the Temnes. After the rice is a few inches high other crops are planted amongst it. Corn, pumpkins, tomato, okro, and even cassava are planted in this way, and of course some of them come to maturity after the rice has been harvested. The

bracken fern grows wild on many Mende rice farms, and its tender unfolding 'leaves' or fronds are sometimes eaten as a spinach. In some districts benniseed, bulrush millet, and Guinea corn are grown amongst the rice. Cotton is sometimes planted amongst the young rice, and comes to maturity and is picked after the rice has been harvested.

Many of these rice farms are several acres in extent, and in the centre of them are specially constructed farm-huts which are covered with grass. In these huts the farmer and his family often sleep during the busier times on the rice farms, and they are also used to some extent for storing the harvested rice.

As the harvest time approaches hosts of rice birds appear and cause considerable damage and loss to the crop. Numerous small boys are employed to scare off the birds, which they do by throwing stones, dried clay, and other missiles. They often sit all day long on specially built platforms (Plate V) and in some districts series of tins are arranged on long strings and the children keep pulling the strings, and the rattling of the tins scares away the birds. There are many other ingenious and home-made devices for frightening the birds.

The rice is harvested in the way already described for swamp rice, except that the heads are stacked on the tree stumps until they are dry.

In some parts of West Africa the plants are pulled up when ripe, tied together in bundles, and left on the farm to dry. In other parts only the heads are cut off and then allowed to dry. The stacking of the dried heads either in the farm-huts or on the farm, or in special stores or stacks in the villages has already been described.

Rice is little troubled by diseases or insect pests, except locusts, which appear periodically and do tremendous damage. The African ground rat pulls up and eats the tender shoots and rice birds eat the grain. In mangrove swamps even fish destroy part of the crop.

Thrashing and Winnowing

When the rice is required the heads are removed from the store or stack and are thrashed in two or more different ways.

The seeds are removed from the heads or sheaves, generally by beating them with heavy sticks and later with lighter sticks to remove the remainder. This method is generally adopted when large quantities are dealt with, although it tends

to scatter and waste some of the seed. When only small quantities are to be done, they are separated by treading out the grain with the feet. The stems are then removed from the heap by hand and are known as 'rice straw'. The thrashed seed is collected and is then winnowed, the seeds being dropped from a height on a windy day, when the chaff is blown away.

Cleaning Rice

The rice after thrashing and winnowing is still surrounded by a tough coat. In this form rice is often known as 'paddy' and can keep for considerable periods, or can be transported with ease.

Before it is ready for eating the outside husk must be removed. This is done in two ways. The first is to pound the seeds in a mortar until the husks are loosened. The disadvantage of this method is that not only are the husks only partly removed, or removed with difficulty, but the grains themselves are often broken in the process. The husks are later removed by a simple form of winnowing by which the pounded seeds are placed on home-made trays and thrown into the air on a windy day, when the loose husks, or 'chaff' as it is called, is blown away by the wind and the grains are left behind.

A much more efficient method of thrashing can be done when the seeds have been specially soaked and heated first. This process, known as 'parboiling', is much more usual and effective, and in Sierra Leone most of the rice is cleaned in this way. The grains are boiled in the evening for a short time, the pot is removed from the fire and the grains are allowed to soak in water overnight. In the morning the water is removed, and a small quantity of fresh water, sufficient to cover the bottom of the pot, is added. The pot is then put on the fire and the small quantity of water prevents the rice from burning and provides steam which swells the rice until the husks are burst. When the husks have all burst, the grains are emptied out and dried in the sun. This process of parboiling makes the separation of the husk from the seed much more simple. The rice is then pounded and the husks come off comparatively easily, after which the husk is winnowed by throwing up the rice in trays on a windy day.

The cleaned rice will keep for a considerable time and is now ready for food.

Varieties of Rice

There are several varieties of rice grown in West Africa amongst both swamp and dry-zone rice. These varieties are

distinguished mainly by the shape and size of the grain, by the presence or absence of an awn or 'whisker', and by the colour of the kernel itself. Some rices are classified as to whether the grain is glutinous or non-glutinous, or whether they are slow, medium, or quick in their period of ripening. Long-grained varieties are not to be recommended as they tend to break more easily in the cleaning process. Most of the West African varieties are either white or red rices. The white rice is known in Sierra Leone as 'American rice' and is said to have been introduced from the United States by the early American missionaries. Most West African rice is brown, yellow, or reddish in colour even when cleaned, and for that reason is not popular in the European market, where it is used mainly for feeding poultry. Even in local markets the red rice is becoming increasingly unpopular as white rice is preferred, and the rapid increase in the amount of imported polished rice from India or Indo-China is the main cause for this. The increase in the number and size of towns and the growth of mining camps in West Africa are mainly responsible for the rapid rise in recent years in the imports of rice. Even most Europeans, as well as Africans, prefer the polished imported rice to the red 'native' rice, which is really much more nutritious and which is, fortunately, still preferred amongst those tribes who grow and eat rice.

Polished Rice

The ordinary grain of rice, after the husk has been removed, has a somewhat dull colour and does not attract either Europeans or town Africans as much as the shining white rice from the East. Many of these Eastern rices, however, were dull in colour until the grains were specially polished by machinery, and African-grown rice can be made to resemble imported 'polished' rice if treated in the same artificial way. Such machinery has been installed at the Government Rice Mill at Essiama in the Western Province of the Gold Coast. Here the Nzima farmers sell their paddy to the Government factory, where it is specially husked and the grains polished by special treatment.

The polishing of the rice is done by machinery, in which the grains have their outer layer removed by means of a rotating drum, covered with leather strips, which gives a final polish to the rice. The outer layer of the cleaned rice which is removed by the polisher is rich in proteins and its removal really decreases

the value of the rice as food, even though it improves its appearance. This outside layer of the grain itself, which is known as the 'aleurone layer', contains the body-building portion of the rice grain, the remainder of the grain consisting almost entirely of starch. The broken portions of the aleurone layer removed in the polisher form a yellowish-brown powder which is known as 'rice bran'. Bran is of high food value, as it is rich in proteins, but it is generally sold as poultry food or used in the preparation of cattle foods, for which, however, there is little demand in rice-growing districts.

Of the other by-products of the rice factory, the husks are useful as fuel and the broken pieces of rice are generally sold locally and are made into pancakes and rice 'kenki', in the latter case the fragments being pounded in a mortar, mixed with ripe plantain and fried in palm-oil. Broken rice is also very useful as a food for poultry.

In those countries and districts where rice is practically the only food, the eating of polished rice causes a disease known as beri-beri, due to a lack of the food materials and vitamins found in the outer or aleurone layer of the rice grain. Although unpolished rice is undoubtedly a much better food than polished rice, there is little danger of beri-beri in West Africa, where the deficiency is made up by the mixed diet of the people, who eat other nitrogenous and vitamin-containing foods.

Polished rice is ground into a powder in Europe, and is known as ground rice, a very starchy substance used in preparing puddings, and also sometimes used to thicken soups. Starch can also be prepared from rice. There are many different dishes that can easily be prepared from rice in any West African home.

Lastly, rice is increasing rapidly as a food in West Africa, owing to its cheapness, ease of transport, keeping qualities, and food value, but most of the rice imported comes from the Eastern tropics. While it is realized that rice is a somewhat specialized and slightly more difficult crop to grow than most, there is no reason why its cultivation could not be considerably extended in the Savannah forest districts, as well as in mangrove and fresh-water swamps, until West Africa is able to produce more and more of its own rice. The Sierra Leone rice from the Scarcies district is sent mainly to Freetown, but some of it is imported into the Gold Coast, which shows with what success rice can be grown in certain parts of West Africa.

CHAPTER XII

GUINEA CORN. MILLET. HUNGRY RICE OR 'ACHA'

GUINEA CORN [SORGHUM SPP.]

THE origin of Guinea corn is uncertain. There are several plants of the same kind which are classified under the genus *Sorghum*, each species having several varieties. These various sorghum grains have been cultivated in the drier parts of Asia and Africa from remote ages, and whether they originated in tropical Africa or were introduced there by way of Egypt or East Africa is uncertain.

The classification of the various types of sorghum is very involved, as there are many different kinds in various parts of the world, of which the best known are probably Kaffir corn, milo, broom corn, feterita, durra, and shallu. The differences are chiefly in the height of growth, shape of the fruiting head, and size, shape, and colour of the grain, and the uses to which the various parts of the plant are put.

The sorghums are divided into the following main groups: (1) grass sorghums, (2) broom corn, (3) sweet sorghums, and (4) grain sorghums. The grass sorghums are grown for their leaves and stems, the broom corns for the stalks of their flowering heads, the sweet sorghums for the succulent stems rich in sugar, and the grain sorghums mainly for their seeds.

1. GRASS SORGHUMS

The types of sorghum which produce a luxuriant growth of stems and leaves and comparatively small seeds are known as 'grass sorghums'. Sudan grass, Johnson grass, and other wild sorghums come under this group, and several of them occur in dry districts, such as Northern Nigeria.

As they are of value for fodder, particularly for cattle, they will not be dealt with here.

2. BROOM CORN

Some types of sorghum produce long seed-bearing stalks in their fruiting clusters. This group consists of the so-called 'broom corns', the long bristles of the fruiting heads being used for making brooms. The heads are cut before they are quite ripe, when the bristles are still green and flexible, and after

drying are used for making brooms. If allowed to ripen first the bristles become brittle and useless, although the seeds can be used for feeding live stock or poultry.

3. SWEET SORGHUMS

In the United States of America varieties exist which contain quantities of sugary juice in their stems, like those of the sugar-cane. These varieties are known as 'sweet sorghums', and a sugary syrup is sometimes obtained from them. One type of sweet sorghum occurs in Northern Nigeria where it is known in Kontagora as *Takanda*. It resembles the common Guinea corn in general appearance, but is usually reaped before Guinea corn is planted. The plant is used in Northern Nigeria for feeding live stock. More often the stems, which are rich in sugar, are used as fodder for animals, particularly cows. The stems are also used in the making of silage.

4. GRAIN SORGHUMS

The most usual types of sorghums are those producing large and numerous grains which are used as food for man or animals or for both. These are known as the grain sorghums, and there are many different types.

The main types of grain sorghums are as follows: (1) feterita, (2) durra, (3) shallu, (4) dry-season corn, (5) Kaffir corn, (6) Guinea corn.

1. **Feterita** (*Sorghum caudatum* variety *Feterita*). This plant grows up to 14 feet in height and has remarkably white grains and is the type of sorghum chiefly grown in the Sudan. It is specially recommended for making bread, as it produces an excellent flour. Twenty-five per cent. of the flour mixed with wheat flour has been tried out for breadmaking in Italy with excellent results. Other varieties of *S. caudatum* are to be found in other parts of tropical Africa.

2. **Durra** (*Sorghum Durra*). 'Egyptian Corn.' This is a variable annual plant growing up to 14 feet in height and producing white, reddish, or yellow grains. It is grown largely in Egypt and the Sudan, in Asia and the United States. There are many varieties of it, de[illegible] seeds. One type is known as M[illegible] n the countries where they ar[illegible] ce of the grain for food, for w[illegible] best types. Although this is [illegible] itish

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West African colonies, there is no reason why attempts should not be made to grow it in the drier regions.

3. **Shallu** (*Sorghum Roxburghii*). This plant grows from 5 to 8 feet in height, and takes from 125 to 140 days to mature. It has slender stems and large loose panicles. It is a native of India, although Stapf mentions two types of it as occurring in Africa, where it is grown in East and Central Africa.

It is best grown under conditions of irrigation which are not yet generally available in West Africa. It is of value as a fodder plant, but is mainly grown for the grain.

4. **Dry-Season Corn** (*Sorghum cernuum*). **Masakowa** or **Mazakwa.** *Hausa*. **Maskwari.** *Fulani*. This type of sorghum grows from 10 to 14 feet in height and is extensively grown in North Africa and in the drier parts of West Africa such as the Gambia, Northern Nigeria, particularly in Bornu and Yola, and elsewhere. It has been introduced to other parts of tropical Africa and to the West Indies, and in all parts where it is grown it is used as a staple food. The grains are fine and white, and are sometimes eaten whole after cooking. The grains are used in Algeria for making bread. It is planted little by little in alluvial soil along rivers as the water subsides and the dry season approaches, and is harvested in February to April.

5. **Kaffir Corn** (*Sorghum Caffrorum*), a type, the name of which implies that it is of South African origin. It is about 6 feet in height and is being grown increasingly in the United States of America where the most popular type is 'Black-hull Kaffir', a variety with almost white grains surrounded by black hulls. Some varieties have red or yellowish seeds, but these are not so suitable for food as the white-seeded ones, owing to the astringent taste of the seed coats. The Kaffir corns also have sweet stems which, although not so rich in sugar as sweet sorghums, are probably the most suitable of the 'grain sorghums' for feeding to stock. Varieties of Kaffir corn (*S. Caffrorum*) actually exist in West Africa in the Bornu region of Northern Nigeria. Kaffir corns are really closely related to the Guinea corns, one American variety actually being known as 'Guinea Kaffir' which is simply another name for Guinea corn. As the Kaffir corns are mainly grown in South Africa and the United States and the closely related Guinea corns in West Africa, the latter will be given a separate section. (See section 6.)

6. **Guinea Corn** (*Sorghum guineense*). This is probably the commonest type in West Africa, although, as we have already

seen, other species and their varieties are found which are generally loosely recognized as different types of 'Guinea corn'. All varieties of Guinea corn are commonly used as food.

The different types and varieties of Guinea corn vary greatly in the height to which they grow, some being only 4 to 6 feet, others 12 to 14 feet, while most of them are 6 to 12 feet high. They are erect in growth, with prop roots like those of corn near the base of their stems, broad leaves, and the flowers and fruits produced in clusters at the top of the plant.

The fruiting heads and seeds also vary greatly; some have short heads and in others the heads are long; some are loose, and others again are compact. The grains or seeds differ in colour also, and there are white-, yellow-, orange-, and red-seeded varieties, with other shades in between. One white-seeded variety has black husks round the seeds, resembling the variety known in America as 'Black-hull Kaffir'. In some the seeds are small, in others large, some have soft seeds and others hard. Sometimes varieties occur which have particularly sweet seeds, or in which the seeds can be cooked and eaten whole.

In West Africa there are many local varieties of white-seeded Guinea corn, and of some of the other types mentioned as well. To attempt to enumerate all these varieties, or to classify them, would be impossible in a book of this size. It would also involve the growing side by side of all the varieties collected in the field, when a more complete comparison and classification of them could then be made from the living material.

Guinea corn is indispensable in those countries and districts which are too dry for maize or upland (dry-zone) rice. It can be grown in districts with as low a rainfall as 15 or 20 inches per annum, but is generally found in those regions where the rainfall varies between 25 and 50 inches. The dry-season corn, as we have seen, is planted at the end of the rains and grows mainly in the dry season, being harvested from February to April. In the Oyo district of Southern Nigeria red Guinea corn is planted on hills in July and harvested in December.

Many varieties are long-seasoned and take six months to mature, being planted in April and harvested in October when the rains cease. Others are quicker in ripening, one variety taking only three months to mature. This three-months variety is much smaller seeded than the six-months varieties, its seed somewhat resembling that of bulrush millet.

Guinea corn seems to do best in those districts where there is

a distinct contrast between wet and dry seasons, and especially in those regions where there is one rainy season instead of two, a large and small rainy season. In the drier coastal plains of the Gold Coast, for example, Guinea corn does fairly well in some seasons, whereas in other seasons when the rains are spread out more evenly over a longer period, the plants do not thrive so well, and the seeds are attacked by moulds. Guinea corn does best when there is a small but continual supply of rain during its period of growth and hot dry weather at the time of the ripening of the seeds. Probably the high humidity of the air near the coast, even in grassy regions, does not suit the crop so well as the lower humidity of the grassy lands in the interior. Also the greater range between maximum and minimum temperature in Northern Nigeria, for example, suits Guinea corn better than the less variable temperature in the more southern and tropical regions.

Apart from the dry-season corn (*Sorghum cernuum*) which does best when planted along alluvial flats near rivers, Guinea corn appears to do well in most soils, except pure sands and clays. Its soil requirements closely resemble those of maize.

In the Niger River districts no manure is applied to this crop, but in the north manuring with farmyard manure is regularly done. The droppings of cows, sheep, and goats are carefully collected in the villages and spread thinly on the soil before the crop is sown. Sometimes the manure is applied to the young plants soon after they appear. In Northern Nigeria Guinea corn is often grown on land on which cattle were 'kraaled' during the previous dry season.

In northern districts Guinea corn is usually planted on a ridge and furrow system. Sometimes the crop remains for only one season, but at other times the roots are allowed to remain in the soil for two or three years, and all vacancies are filled with new seed as the old plants die. While this is, in some ways, a disadvantage in preventing fuller tillage of the land, especially if and when proper ploughing is introduced, the crops grown by this method appear to withstand drought better than those sown every year. When the old plants are allowed to stay over a second or third season, farmyard manure is often sprinkled round their roots at the beginning of the rains.

In Northern Nigeria Guinea corn is often grown on farms for a number of years without change. It is sometimes grown with bulrush millet, the Guinea corn being grown on the ridge and

the millet in the furrow. When the soil from the ridge is pulled into the furrow which therefore becomes a new ridge, and the old ridge becomes a furrow, the process is reversed. The ridges are generally made 3 or 3½ feet apart and the seeds can be sown 1 to 2 feet apart in the rows, four or five seeds being placed in each hole, and the plants sometimes thinned out to two to three per hill when about 6 inches high. On some occasions blanks are actually filled by transplanting seedlings into them.

In the drier districts of Yoruba country in Southern Nigeria yams are sometimes planted as the Guinea corn ripens, and after the cutting of the heads the Guinea corn stems are bent over horizontally and serve as supports for the growing vines of the yams. Cow peas are sometimes planted amongst the Guinea corn, thereby adding nitrogen to the soil, and the peas are harvested with the Guinea corn in December.

In Northern Nigeria much damage is done to the Guinea corn crop by a root parasite (*Striga sp.*). This pest is best removed by hand when it is in flower.

As the time of harvest approaches and the seeds begin to form they are sometimes attacked by moulds and other fungous diseases, particularly when the humidity is high or the weather rainy. In dry weather the risks of attack by such diseases are greatly reduced. Amongst the greatest enemies of the farmer are the hosts of birds which appear in the harvest season. These are often frightened away by small boys or by various scaring devices adopted by the farmer.

When the seeds are fully ripe the stems are cut a few inches below the heads with a sharp knife. The heads are sometimes dried in the field, or sometimes taken direct to the village to be dried, or often both methods are adopted. (Plate VI *a.*) In the Oyo district of Southern Nigeria the heads of red Guinea corn are cut and dried in December, sometimes being laid flat on the ground, or tied together in bundles and placed, cut end uppermost, on top of the bent-over Guinea corn stalks. In this way they receive more air and sunshine and dry quicker.

The dried heads are stored in various ways. In parts of the Gold Coast, and in Nigeria also, they are stored in special home-made 'bins' made of swish, and with little grass roofs. Sometimes these bins are built on a foundation of stones.

The seeds of Guinea corn are specially liable to be attacked by weevils during storage, and at the end of the dry season it is increasingly difficult to find samples in the markets which are

not attacked by these destructive little boring beetles. Some African farmers take special precautions to prevent their stored Guinea corn from being attacked, which is specially important when it is being kept for next year's planting. One precaution taken is to store the seeds in earthenware pots, to which ashes are added, the ashes appearing to lessen the chance of weevil attack.

In parts of Togoland the heads are bound up in a hand-woven bag made of the leaflets of oil palm, and known in Ewe as *Klɛ*. This is closely woven, so that no seeds can drop out, and it is then hung up in kitchens where the smoke under the roof helps to keep away weevils, and in such a position as to be difficult for rats and mice to reach it. A small white-seeded variety known by the Hausas as *farafara* is considered to have the best storing properties.

After the heads of Guinea corn are thoroughly dried, and either before, but more usually during, their period of storage, they are thrashed to remove the seeds from the heads. The thrashing is generally done by pounding the heads in mortars, or on the floor or ground with heavy sticks known as flails. (*Plate VI b.*) The husks are removed by winnowing, as in other cereals, and the grains themselves are either sold direct in the markets, or stored first. As so many of the seeds sold in the markets are riddled with weevils, the greatest care should be taken to prevent this by storing them properly in air-tight tins or other receptacles.

The uses of the seeds are many. The seeds of grain sorghums are used in many parts of the world in making intoxicating drinks, and in West Africa Guinea corn is largely used for this purpose. The pagans of Northern Nigeria use an inferior red-seeded variety in making a drink known as *peto*. In Yoruba districts of Southern Nigeria red-seeded varieties are specially sprouted in balls wrapped in leaves (sometimes of *Jatropha Curcas*). The sprouting of the seeds in this way provides the 'malt' necessary for the brewing, and these balls of sprouted seeds are specially sold in the markets for the making of local 'beer'.

The smaller seeded varieties afford excellent food for poultry, and can be fed either whole or in a 'cracked' or broken state. Other varieties, particularly the red-seeded ones, are often used for feeding horses. A large yellow-seeded variety known in Hausa as *Kaura*, however, is considered to be best for horses.

The main use of Guinea corn, however, is as human food. Guinea corn is richer in proteins (especially albuminoids) than maize. The flour made from Guinea corn is sometimes used for making bread, as in Algeria and elsewhere, and is white and of good appearance.

Guinea-corn flour is prepared in various ways for numerous foodstuffs in West Africa, and it is unnecessary to go into all the details here. The flour is generally mixed with water and made into foods resembling porridge.

In some cases the grain is cooked and eaten whole, as in dry-season corn, and in some of the softer and sweeter grained varieties in West Africa.

One red-seeded variety produces seeds which are not generally eaten, and are said to give colic to animals. These seeds are used in African medicine. This variety is used for the manufacture of a red dye, the stems or leaf-sheaths being dried and pounded, and potash being added. The resulting red dye is used for staining grass mats or dyeing leather the familiar red colour.

The 'bran' obtained in the making of Guinea corn flour is used as fodder for cattle and horses.

The stems and leaves of Guinea corn are sometimes cut and used in the green state as fodder, or they can be used as silage, if necessary, or fed in the dried state as hay. In the latter case the leaves are stripped off before the plant is mature, dried in the sun, and stored for future use.

The sorghums, whether grass, sweet, or grain sorghums, have been found by world-wide experience to be unsafe to use as green fodder when the leaves are young. Many cases of poisoning arising from feeding the younger leaves to live stock have been reported, the poisoning being said to be due to prussic acid. It is now generally agreed that it is only safe to feed the stems and leaves to live stock, or pasture them upon it, no earlier than the time when the plants are in flower, or just before that period. In the Zaria and Kano Provinces cattle and even sheep and goats are kept muzzled when the Guinea corn is young and green, for the above reasons.

The dried stems of Guinea corn are used for various purposes in Northern Nigeria, such as in the making of screens and fences. Some of these fences act as effective barriers against the cold winds from the north. The stems are also used for fuel, for the making of baskets and mats, for thatching houses, and as the supports for gourds, yams, and beans on farms.

BULRUSH MILLET
PEARL MILLET [PENNISETUM TYPHOIDEUM]

Gero or **Giro**. *Hausa*.

The bulrush millet plant is believed to be of West African origin, being one of the few West African food plants which has not been introduced.

It is a member of the grass family, and grows to a height of 5 to 6 feet or more. The flowering and fruiting head is compact and forms what is called a spike, just as the loose flowering heads of the Guinea corn form a panicle. The resemblance of the head of the millet to that of the common bulrush accounts for its name 'bulrush millet', just as it is also sometimes called 'spiked millet' because of its spiked head of seeds.

The leaves of bulrush millet are light green and hairy. It readily produces shoots round the base of the original plant. This process is known as 'tillering', and the new shoots produced are called 'tillers'. The final yield of seeds per head does not appear to be reduced by the number of tillers produced per hill.

The seeds of certain varieties of millet are grey and pearly in appearance, hence its common name of 'pearl millet' in the southern United States.

There are several varieties of millet grown in West Africa. These can be divided in two main groups: those varieties taking three months, and those taking five to six months to produce seeds.

There are two types of short season (three-months) millets: those with smooth seeds, and those with awned seeds. The short hair-like growths found on the seeds of certain members of the grass family are known as 'awns', so that the head of this awned variety has a more hairy appearance.

Bulrush millet is a drought-resisting plant, and is, in fact, the cereal crop that can grow and thrive in drier districts than any other cereal crop.

There is another variety, taking four and a half to six months to mature, which has large, smooth, greyish-white grains. It is known in Hausa as *Maiwa* or *Dauro* and is cultivated in much the same way as Guinea corn. It does well under the same climatic and soil conditions as those which suit Guinea corn, so that it grows farther south and in a somewhat moister climate than the three-months variety of millet. In Nigeria this five- to

six-months millet is uncommon north of Zaria, but the Gwari pagans living south of Zaria grow it in large quantities.

Bulrush millet will grow best in rich well-drained soils, although it does well in loams or even in sandy loam soils. It will germinate with less moisture in the soil than almost any other crop.

In Northern Nigeria it is often grown along with Guinea corn. The land is first ridged and the millet is planted in the furrows, in the early rains, about the middle of April, the Guinea corn being planted on the ridges later. If the rainfall is poor and the Guinea corn likely to fail, a second crop of millet is sometimes put in, as it is much less likely to suffer from drought. Sometimes the millet is grown alone, and one or two crops per year are raised, depending on the annual rainfall of the district.

Millet can grow with very little rainfall after the seed has once germinated. During the earlier and leafier stages of its growth it does better if it has a certain amount of rain, although too much rain does definite harm. Light rainfall during its growing season is beneficial, and the crop does better if the soil is kept free of weeds and well broken up, especially after each fall of rain. During the time of flowering and setting of seeds it is better that the weather should be hot and dry. The crop does well in open situations where it is not shaded by trees. The seed ripens well in very dry weather, for if the weather is at all wet, or even misty, the seeds are sometimes attacked by moulds which spoil the yield and quality of seed. It is for this reason that millet generally does so poorly in the coastal plains, because of the high humidity, or in the forest because the rainfall is too heavy for it. The crop needs a greater variation of temperature, hotter days and cooler nights, and much less rainfall and humidity in the air. This is why it thrives best in northern regions towards and in the Sudanese zone.

As the seeds ripen, millet is attacked by numerous small seed-eating birds of the finch family. Children are generally stationed all day in the millet farms, and scare away the birds by rattling tins, throwing stones, or by other methods. When fully ripe, the stalks are cut below the head, and the spikes are first dried and then stored. In certain regions the heads are sometimes arranged in bundles by plaiting the stalks together in the middle, with the heads at the outside, and the bundles are rolled up and carried on the backs of oxen or donkeys.

The seed is sometimes stored in the spikes, or the seeds may

be thrashed from the spikes by pestle and mortar, by sticks, or in other ways. The husks are winnowed by wind. (Plate VII *a.*) The seeds keep in good condition for long periods.

The seeds make an excellent food for poultry in those regions where it is too dry to grow maize or even Guinea corn. In South Africa it is used extensively for that purpose.

A kind of flour is sometimes prepared from the seeds by grinding them between stones. It is then mixed with water and made into a thin porridge which is eaten in many districts where this crop is grown. In Nigeria the seeds are sometimes ground up, mixed with milk, and eaten in the uncooked state.

The grain can also be used as cattle food.

Sometimes the seeds are malted, and an intoxicating drink known in Hausa as *gir* is obtained from them.

The leaves of millet are of value as fodder for cattle or horses, but are coarser in quality than those produced by Guinea corn. In parts of India the plant is used in the green state as fodder. When cut in the young green state it is much less woody and therefore of more value for feeding stock.

HUNGRY RICE [DIGITARIA EXILIS]

ACHA GRASS (Acha. *Hausa*). FUNDI. *Sierra Leone.*

This is an annual grass about 1½ feet in height. It produces numerous very small seeds which are generally yellow in colour.

This crop is grown in Sierra Leone, mainly in Temne districts. The Temnes are supposed to have learnt how to grow it from the Susuas and Fullahs during wars with them. The plant has obviously been introduced into the country from the north and is one of the main foods of certain tribes in French Guinea and also in the Gambia. It is also grown in Northern Nigeria by the Hausas, in Bornu, and by certain pagan tribes, especially in the Bauchi region.

In Sierra Leone it is usually sown after rice, or as a substitute for rice when the season is unfavourable for a good rice crop. It will grow practically anywhere and is generally planted from April to June. The method of planting is practically the same as that of rice, the seed being scattered broadcast and hoed lightly in. It germinates after three or four days and grows rapidly, spreading over the ground so that it is not necessary to do much weeding. It is ripe in three or four months after

planting, and as it ripens it is necessary to scare birds away from the seeds.

It will grow in most soils and does well even in light soils and with a low rainfall. Crops can be grown even in rocky situations such as exist on the Bauchi plateau. In Northern Nigeria it is sometimes grown in fields with millet, or sown broadcast as a field crop.

Knives and curved sickles are used to harvest the crop, which is cut in handfuls, and tied into small sheaves. After drying these are kept in dry positions in huts. The grains are removed by beating or trampling with the feet (Plate VII *b*), and after the seeds have been dried again in the sun, the husks are removed by beating the grain in a mortar, the chaff being winnowed away by the wind, leaving the clean grain behind.

The straw is used in Sierra Leone for stuffing mattresses and pillows.

The grain is used in various ways as food. In Sierra Leone it is generally thrown into boiling water for a few minutes, after which the water is removed and the grains are finally cooked for a short period over a slow fire. It is eaten mainly by the Temnes usually with soup and spinach. Sometimes palm oil, butter, or milk are added, or it is made into a milk porridge, or is eaten with fish or meat. In French Guinea it is stated to be the principal food of the people, and according to Chevalier the taste is so pleasant that even Europeans relish it. (Chevalier, *Mission au Sénégal*, p. 241.)

There are several varieties of fundi grown in Sierra Leone.

According to Faulkner, other minor grain crops grown in Nigeria are 'Iburu' (*Digitaria Ibura*) and 'Tamba'. Iburu is grown by the pagans of Bauchi and Zaria, and is sown broadcast. Tamba has larger grains, is usually grown on ridges, and is more carefully cultivated.

CHAPTER XIII

CASSAVA (*Manihot utilissima*)

The cassava plant, which is a native of South America, is a shrub growing from 6 to 12 feet in height, with smooth stems and leaves. The stems and foliage vary greatly in colour, the nodes are distinctly marked, and the leaves are deeply lobed. Some varieties produce flowers, which are yellowish-white and are followed by round fruits which contain three seeds. (Fig. 11.) Some of the seeds, when planted, will grow.

There are two main types of cassava, namely, bitter cassava and sweet cassava. Bitter cassava, as its name implies, contains more bitter juice in its roots, and it is poisonous unless thoroughly soaked first. The bitter juice contains prussic acid (hydrocyanic acid) which is poisonous if the roots are eaten raw. In sweet cassava, prussic acid is also present, but in much smaller quantities, so that it is driven off as a gas when the cassava is cooked. In bitter cassava, however, the roots need to be cut into pieces and soaked in water for a day or two so as to remove most of the poison, after which the roots can be cooked and eaten in the usual way. The water in which the bitter cassava roots have been steeped contains prussic acid, and great care should be taken to throw it away at once afterwards, as several fatal cases of poisoning have occurred through human beings and domestic animals drinking the liquid. In the West Indies this poisonous juice is boiled to the state of a brownish syrup-like liquid, to which capsicum peppers are added, forming the well-known 'pepper pot' which is used as a basis for various sauces. This liquid is known all over the world as cassareep.

The bitter cassava is grown more extensively in the West Indies and other parts of the tropics, but in West Africa the sweet cassava is the kind most commonly seen. The bitter cassava generally grows taller than the sweet cassava, takes longer to mature, and produces larger roots and heavier crops. The stem is whitish and the roots are also lighter in colour. There are varieties of cassava between these two extremes, that is some varieties of sweet cassava occurring in West Africa contain more bitter juice and need more soaking and boiling than other varieties.

There are at least twenty distinct varieties of cassava grown

on West African farms. Some are quick-maturing, others slow-maturing, their periods of growth varying from five months to fifteen months or more. If they are required for food they are generally dug early before they become too fibrous and woody, while if they are only required for making flour they may be left

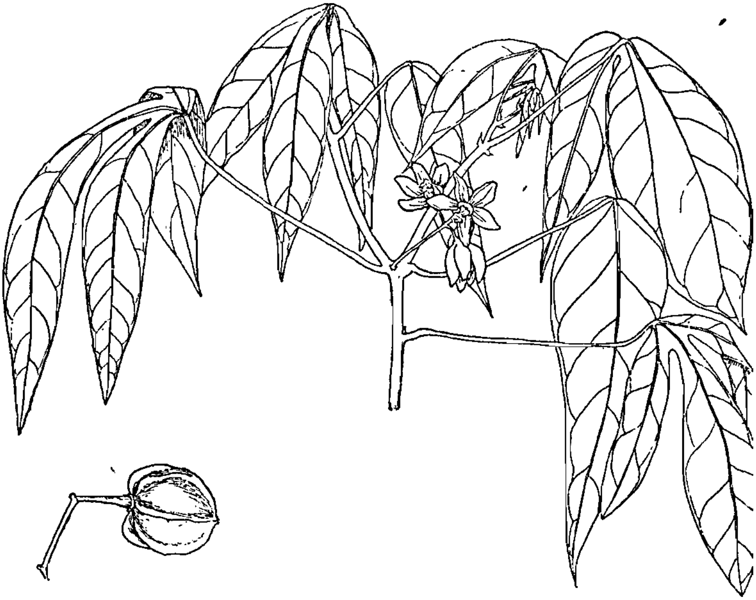

FIG. 11. Cassava, showing flowers and fruit.

for as long as eighteen months, or in rare cases even for two to three years.

Some West African varieties are distinguished by the leaves, which vary considerably in shape, number of lobes, and colour of the petiole or leaf-stalk, which may be white, yellow, green, pink, or red; or sometimes with two colours alternating. Two varieties have particularly striking leaves, namely 'cotton-leaved cassava', a variety with broad leaf lobes which overlap each other slightly and leaves shaped somewhat like those of cotton; and 'sessile-leaved cassava', a variety with little or no leaf-stalk, so that the lobed leaves appear to be attached direct

to the stem, which gives the plants of this variety a very curious appearance.

The main differences between most of the varieties appears to be in the colour of the stems and the skin of the roots. Some have dark grey or blackish stems and dark coloured and numerous roots; others have red or reddish-brown stems and brown-skinned roots with smaller and fewer roots than the dark-skinned varieties; and others again are white-stemmed with white-skinned roots which are often larger than those of the dark grey and red varieties. There are minor differences in the stem; one variety, for example, being called 'Bamboo' because its knotted stems somewhat resemble those of bamboo in appearance. The colour and shape of the petioles and leaves also vary. Varieties differ slightly in the times they take to mature and in the quality of the roots for the making of starch, 'fufu', and cassava meal.

Cassava grows best in a rich, well-drained loamy soil with a light or medium rainfall. It thrives in most parts of West Africa, even in the moister climates of the closed forest country. In Ashanti it is increasing in importance and tending to replace the coco-yam, while in Ibo country the cassava is rapidly replacing the yam, as it is easier to grow and produces a greater yield of food per acre. Cassava will not grow properly in badly drained swampy soils, where the roots tend to decay, and in regions of high rainfall a dense growth of leaves is produced at the expense of poor root growth. Cassava seems to do best in West Africa in the lowlands near the sea, where soils are often light loams and the climate hot and dry. It responds to manuring, but only in parts of Nigeria do the people take the trouble to manure the crop, the Nupes using it as a cover for their onion crops, in the manuring and cultivation of which the cassava benefits. Cassava is not adversely affected by strong winds and does not require any shade.

Cassava is said to be the most productive crop in the world. It produces six times as much food material for man as a similar area of wheat. Just as it is a heavy yielder of food, so it is an exhausting crop; and if cassava is grown twice or more on the same piece of land the yields rapidly decrease owing to the amount of plant food which this crop takes out of the soil. The rapidly increasing extent to which cassava is being grown in West Africa, especially near the larger towns where great areas of cassava are often seen, is a great danger to agriculture, as the

fertility of the soil is being rapidly used up. Unless some form of rotation of crops, application of green dressing, or manuring is practised, it will soon be difficult to grow good farm crops at all on these areas which excessive cropping with cassava have impoverished.

Cassava is one of the easiest of crops to propagate and grow. Pieces of stem, 6 to 8 inches in length, are generally taken and planted either erect or in a sloping position in damp soil after rain, with one-third or one-half of their length buried. These cuttings are generally planted 4 feet apart both ways, and usually produce leaves and shoots quite soon after planting. It is a common mistake for school-children to plant some of their cassava cuttings upside down; so that care should always be taken during planting to see that the small buds are *above* and not below the leaf-scars.

Frequent weeding and surface cultivation of the soil during the time of growth assist the plants to produce good crops of roots.

The mature roots are dug as required, and as the dry season approaches the plant sheds most of its leaves, but the stems and roots usually endure throughout the dry season, the stems putting out new growth in the following rainy season. If the roots are left when this new growth takes place, they are not liked as food at this stage.

When the roots are dug up, unless prepared for food within two or three days, they rapidly go bad and the flesh of the roots becomes discoloured and unsuitable as food. This is prevented if the roots are buried again, as they appear to keep indefinitely underground and can be kept until they are needed for use.

The cassava plant in West Africa is generally little troubled by insect pests or diseases. Within the last three or four years in the Gold Coast, however, a disease known as cassava mosaic has been spreading rapidly. Mosaic diseases occur on other farm plants as well and attack the leaves, giving them a characteristic mottled appearance. They become blotched with irregular patches of pale and dark green, the pale green patches being the infected portions. The irregular infection of the tissues of the leaves causes them to wrinkle up, so that they become somewhat smaller than normal leaves, and their colour and wrinkled appearance make them quite conspicuous, even from a distance. Naturally any disease of the leaf prevents

the proper formation of starch which is prepared in the leaf, and therefore the amount of starch sent to the roots is correspondingly less and poorer crops are produced.

The cause of cassava mosaic is not fully understood as yet, but it belongs to a group of diseases known as 'virus diseases' which are often spread from one plant to another by insects. Which insects help to spread the disease and how they do so has not yet been discovered in West Africa, although a certain kind of fly (an Aleurodid fly) has been suggested as the carrier of the disease from plant to plant.

From experiments made in the Gold Coast it has been found that most varieties of cassava are susceptible to mosaic disease. Only two local varieties, by name Sareso and Calabar, have been discovered to be resistant so far.

In the meantime the disease may be checked somewhat by the growing of disease-resistant varieties, as no cure for cassava mosaic has so far been discovered. It is unfortunate that some of the most useful varieties are the most susceptible to this disease, and that those which are immune are not necessarily the best for food, although the variety known as Calabar is a good all-round type, worthy of more general cultivation.

It has also been noticed that plants grown under best conditions and on good soil are not attacked to the same extent as plants grown on poor soil.

It has been suggested that the continual growing of cassava from cuttings has caused West African cassava to lose some of its vigour and thus to be more susceptible to the disease. Most of these varieties probably originated from naturally sown seed, but their continual propagation by vegetative means since has decreased their vigour, so that if some varieties were now raised from seed again they might be found to be more vigorous and therefore resistant to mosaic. Further trials of this kind must be carried on in West Africa before the best methods of dealing with cassava mosaic can be stated with certainty.

Cassava roots are often attacked by rodents or gnawing animals, which dig away the soil and gnaw the starchy roots. The large edible African ground-rat, the ground-squirrel, and other animals cause trouble to farmers in this way, and are either shot or trapped by farmers, or prevented in other ways from entering cassava plantations.

USES OF CASSAVA

The cassava plant has many uses. In West Africa it is often boiled and then pounded in mortars into a sticky ball of starchy material, known in many parts as 'fufu'. In this form it is generally eaten with soup or stew.

The roots are often skinned, cut into pieces, and dried in the sun. This is known in many parts of the Gold Coast as 'kokonte'. When this has been done they can be kept for considerable periods. If kept too long, these dried pieces of cassava are sometimes attacked by small beetles or weevils which bore holes through them, and unless they are kept in a dry place they are often attacked by moulds. The black and green moulds which grow on the dried cassava at this stage are considered by some people to improve the flavour! These dried roots can be grated later and made into a flour which is used in the preparation of certain cassava foods.

Cassava Meal (Gari)

This is one of the commonest forms of food prepared from cassava in West Africa. The roots are first washed and peeled, cut into pieces and reduced to a coarsely grated pulp, which is then put into a canvas or muslin bag and pressed for four or five hours until the poisonous juice is squeezed out. On a large scale the grated pulp is often put into small sacks which are stood up on end with the mouth tied up, and several heavy stones are placed on top. These serve to press the juice from the pulp and are left in position for two or three days. The sacks are then opened, the pulp, still moist, is partially dried in the sun, and then heated over a *slow* fire. In some parts the bottom portion of a large broken earthenware pot is used and placed over a fire and the grated cassava is put on in small quantities and stirred continually with a broken piece of calabash or other stirrer to prevent any pieces from burning. Any remaining poisonous juice is rapidly driven off as a vapour. When the cassava is of a yellowish or pale brown colour it is ready, and is known as Gari or Gali and is used for food in many parts of West Africa. It keeps well in this state as it is well dried and partially cooked.

Cassava Starch

The fresh roots are washed, peeled, split into pieces, and finely grated, put into muslin bags or cloth bags of any kind, and clean water is poured over the bag in small quantities at a

time, sufficient to soak the contents, which are then pressed with the fingers. A white milky liquid comes out and is put into shallow basins; more water is poured over the grated cassava, and the liquid is pressed out until it is no longer white. The white colour is due to the starch present, and if the liquid is allowed to stand in the shallow basins for several hours the starch gradually settles at the bottom of the basin and a dirty yellowish-coloured liquid is left at the top. This contains the poisonous portion of the cassava roots and is poured off, leaving the starch which has settled at the bottom. Many people proceed to dry the starch at this stage, but it tends to be yellowish and develops still more colour if kept long, owing to the impurities still left in it. It is better, therefore, to wash the starch again, by pouring clean water over it, stirring it up thoroughly, allowing the starch to settle, and pouring off the top liquid, which is this time not so yellow. If this is done three or four times the top liquid becomes practically clear and the starch is of a much finer and whiter appearance and keeps better. It is then dried thoroughly in the sun and is used mainly in the starching of clothes, so that it is not necessary to buy imported starch.

Tapioca

Tapioca, a form of starchy food which is useful for children and invalids, is on sale in many European stores in the larger West African towns, but it is not generally realized that its manufacture is so easy that it can be made in most West African homes and is already being prepared in some places. Cassava roots are taken and cassava starch is made in the manner already described. Before the starch is finally dried, however, it is put on a sheet of metal, over a slow fire, or the bottom of a large broken earthenware pot is used in the same way as in the preparation of Gari. The moist starch is stirred continually to prevent it burning. As it is being cooked the particles explode, owing to the starch grains expanding, bursting, and turning themselves inside out. The soft, moist starch gradually bursts and forms numerous more or less round and light particles of a white colour, which are known as tapioca.

There are two grades of tapioca, known commercially as pearl tapioca and flake tapioca. Pearl tapioca is in the form of small round pellets, as already described, whereas flake tapioca is in a finely divided flaky form made by spreading out the starch finely before cooking.

The bursting of the starch granules caused by their partial cooking has the effect of making the cassava starch much more digestible.

Cassava is used for other domestic purposes such as the making of cassava cakes, which are fried and eaten with meat and vegetables and are an excellent substitute for English potatoes, besides being an excellent table food for Africans.

Cassava starch, together with rice starch, arrowroot starch, and corn starch, is one of the main commercial starches, and has been suggested as a source of glucose sugar and of alcohol, the latter being suggested for use in the driving of engines in the same way as petrol. Alcohol used for this purpose is called power alcohol.

The average yield of cassava, as investigated in the Gold Coast and Nigeria, varies between 4 and 10 tons per acre.

CHAPTER XIV

YAMS

Yams are perhaps the most difficult crop to study thoroughly in West Africa. Few crops grown on West African farms seem to have so many varieties with only slight differences in the leaves, stems, and underground tubers, so that only practical farmers who grow them every year can distinguish the various differences with certainty. Even then farmers generally know only the varieties grown in their own districts, and those in other districts are often quite different. Sometimes the same yams have different names in the same language areas. In other language areas and places where other dialects are spoken the names are quite different. In a small country like the Gold Coast, for example, there must be dozens of vernacular names for yams in all the various language areas. In Nigeria there must be many more.

Although yams are so widely grown in parts of West Africa and form the main food of certain tribes, as for instance amongst the Ibo people, they are found in most parts of the tropics, particularly in India, Malaya, and the Eastern tropics, where many varieties are reported. In the West Indies the different kinds of yam grown are in all probability of West African or Eastern tropical origin, except the Cush-cush yam (*Dioscorea trifida*), which is American. Some varieties were carried to the West Indies in slave ships often by way of Portugal. While it seems certain that a number of common yams grown to-day in West Africa were originally introduced from other parts of the tropics, it is also true to say that many yams seem to be native to this part of Africa. One only needs to look about carefully in the bush to find several wild yams with typical heart-shaped leaves, smaller than those of cultivated yams, and with much smaller tubers. Before West Africa was opened up properly, some of these wild forms were eaten in times of famine or scarcity, and even to-day some more or less wild varieties are eaten in certain localities after prolonged soaking and boiling.

A careful study of every available kind of yam, not only in the yam store, but in the growing state on farms, shows that they can be divided into six or more main groups which can be roughly separated from each other. In the first two groups,

yellow and white yams, the line of division is not so distinct as that between other yams, so that with some varieties it is difficult to say whether they are white or yellow yams.

The six main kinds which will be dealt with here are (1) white yam, (2) yellow yam, (3) water yam or winged yam, (4) three-leaved yam, (5) Chinese yam, and (6) bulbil-bearing yam.

1. WHITE YAM

This yam is generally held to be of the best quality. There are many varieties of it grown on farms, varying greatly from each other in size and shape of tubers and the colour of their flesh, in the amount of prickles on their roots and stems, and in the shape of their leaves.

White yams when growing are generally distinguished by their longer and narrower leaves, which are roughly triangular in outline and do not have such a deep depression at the top. Their colour is pale green and the veins are in furrows. The tip of the leaf is long and narrowly pointed.

Before planting, the soil should be thoroughly prepared. Yams need good rich loamy soil, and will not do well either in stiff clay or in soil that is too sandy. In drier regions, or where the soil is stony or gravelly, it is advisable to dig deep holes, at least 2 feet wide and 2 feet deep, removing the poor subsoil, or the stones and gravel, and replacing them by decaying leaves or manure and rich black surface soil. Even in rich soils it is good to dig holes and to replace the loose rich soil, as it all helps the tubers to develop better in the looser soil in the hole.

In most parts of West Africa large mounds or hills are prepared, generally two feet or more in height. (Plate VIII *a.*) In Ibo districts large mounds, 3 or 4 feet high or even higher, are made, and as some of the best yams in West Africa are grown there, it would be well if larger mounds were made in other districts. These mounds or hills are made by collecting the surrounding surface soil, and they should be 4 to 5 feet apart, or farther if the variety is a strong grower. Weeds and decaying humus, animal manure or ashes can profitably be added to the hills or put into the holes. The hills are then ready for the yams to be planted.

In some Yoruba districts cow peas are planted during the small rains and yam hills are prepared in October and November. After the peas have been picked the plants are allowed to remain on the soil and act as a cover crop over the yam hills as

well, during part of the dry season. The peas enrich the soil and also keep it moist in the yam hills at a time when it is greatly needed.

For planting farmers use either cut portions of larger yams, preferably the 'top' or stem end (Fig. 12), or small yams as 'seed', the weight averaging 10 to 14 ounces. It has been found

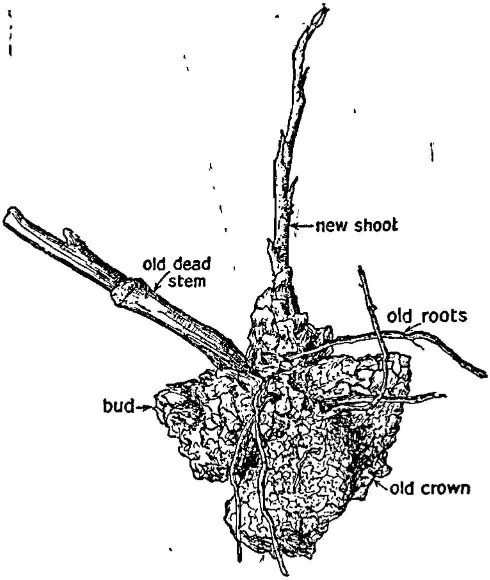

FIG. 12. Yellow yam sprouting from old crown.

by experience that uncut yams yield the biggest crops, large uncut seed yams producing bigger crops than small uncut yams. (Fig. 13.) Most farmers cut up their yams into two or more portions before planting. Some farmers have a special knife for the purpose, and most of them realize the value of using a clean knife. The stem end is sometimes called the 'top', the centre portion the 'middle', and the lower portion the 'bottom'. Tops, middles, and bottoms are sometimes divided again, if the original yam was a large one, although sets taken from very large yams do not do so well. The cut 'sets', as they are called, should not be planted immediately, but should be stored in a shady place or covered with grass for one day, or until the cut surface has

become dry, as, if planted immediately, they tend to rot in the soil. The cut surfaces are sometimes rubbed with wood ashes, or, by some tribes, with cotton leaves. Yoruba farmers then lay the sets in a shallow trench, close together and in one layer only, always with the cut portions uppermost. The sets are then covered with a few inches of soil and uncovered again three or four weeks later when it is easy to see which sets are good and which are bad. The good ones are planted on the farm, and, if

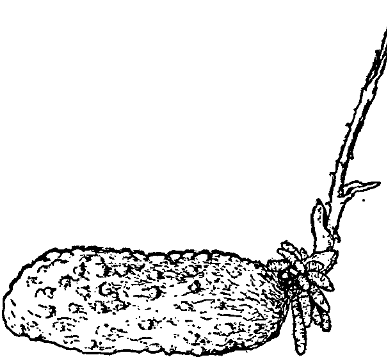

FIG. 13. White yam sprouting from the 'head' end of a complete tuber.

shoots have developed, the whole sprouting set is transplanted on the farm.

The farmer prefers to plant in the early morning, as he insists that the strong rays of the sun are not good for the sets which should be planted in a cool seed-bed or hill.

Experience has shown that whole seed yams and tops sprout at about the same time, although whole pieces of seed yams give slightly heavier yields than tops. Middles and bottoms, on the other hand, generally sprout later and sometimes cannot be relied upon to sprout at all. Their yields are somewhat lower than seed yams or tops. Bottoms give slightly better yields than middles which can be relied upon least.

The time of planting varies greatly in different districts. The Yorubas of the Oyo district, for example, plant their yams in November so that they remain in the hills throughout the dry season and start growth with the first rains in the tornado season in March. In other dry districts this practice does not

seem to work, as the yams shrivel up and decay, or are attacked by boring beetles and white ants or termites, so that in such places it has been found by experience that it is better to plant in March or April. In the dry parts of Yoruba country where November planting is practised, better results occur than if the yams are planted in March. This has been proved not only by the long experience of Yoruba farmers, but also by experiments conducted by the Nigerian Agricultural Department, who tried planting yams in both seasons and obtained best results and heavier yields from the African method of planting in November or December. Some of these early yams are even planted in January or February. The reason why this early planting should succeed in some dry districts and not in others is difficult to explain, and may be due to secondary climatic causes not fully understood, to slightly different methods of treatment of the soil or the yams not yet properly studied, to the growing of certain drought-resisting varieties, or to a combination of all these causes.

In certain Ibo districts one variety is grown specially early, and is planted in the damp flats along river courses, or in the beds of streams which have almost dried up in the dry season. This variety is quick-growing and is harvested before the main rainy season sets in.

In most parts of West Africa the yams are planted after the long dry season is over and the tornado season has begun. The times when these early rains come varies in different districts, so that in wetter regions planting is practised earlier than in drier districts. Most yams are generally planted in the months of February, March, or April, depending upon the earliness or lateness of the particular season or upon the district. In Northern Ashanti, where considerable quantities of yams are grown, it is a common saying that farmers who want a good crop of yams must plant before Good Friday.

The 'seed' yams should be pushed into the middle of the hill, practically at ground-level, with the cut portion always pointing upwards and the skin containing the 'eyes' or buds pointing downwards. It is better to plant them too deep than too shallow, as the stems will always find their way to the light; whereas if they are planted too close to the surface they often dry out and do not sprout, and if the season is at all dry they crumble to powder.

After the yams have been planted the hills should be 'capped',

that is, a thick layer of dried grass or weeds should be placed upon the top of the hill and kept in position by a thin layer of soil on top. It is partly owing to this system of capping hills that the Yoruba farmers in the drier regions such as in the Oyo district are able to keep their yams alive during the long dry season. The Agricultural Department conducted experiments with capped and uncapped hills and found that the yield of yams from capped hills was almost double that from uncapped hills. They also found that January was the best month in which capping should be done. Even if yams are planted in the tornado season in February or March, capping is useful as it keeps the moisture in the hills, thereby helping the yams to sprout, and it also protects the sprouting yams from the sudden spells of dry weather and scorching sun which often come between the tornadoes. The temperature in capped hills varies less than in uncapped hills, and a steadier temperature is better for growing plants. As the rain-storms in the tornado season are often of great violence the grass 'caps' are sometimes blown off the hills and the mounds of earth are partly washed away, and sometimes the 'seed' yams are exposed or even washed out of the hills. They should be replaced as quickly as possible and new grass 'caps' put on. It is also advisable to bank up the hills again with fresh soil so as to form a thicker layer of soil between the yam itself and the outside air. This process is known as 'hilling up' which together with 'capping' form the two main cultural processes to be followed in the planting season. Hilling up should be practised throughout the whole growing season, as at no time should the tubers be exposed to the outside air and to the light.

As the young shoots appear above ground large yam poles, cut from strong hard-wooded plants, should be inserted. Soft-wooded quick-growing plants are generally useless as they quickly rot or are attacked by termites at ground-level, and towards the end of the season break under the strain of the heavy foliage. It is always best to soak the bottom 3 feet of the poles in tar or solignum before the poles are stuck in. This prevents decay or attack by insects at ground-level and poles treated in this way can often be used for another season.

In some Yoruba districts yams are planted after late maize and Guinea corn, the yam hills having been prepared amongst the corn and Guinea corn. After the corn or Guinea corn has been harvested, the dried stalks are bent over at 2 to 3 feet

above the ground and laid in rows, like continuous fences. As the yam vines grow they are trained along the dried Guinea corn or maize stalks. By this system the farmer finds it unnecessary to use special yam poles, which is a great advantage, as wood is so scarce in these districts.

On the Ibadan Agricultural Station special plantations of madre (*Gliricidia maculata*) are made. This is a quick grower and produces long straight branches which, although soft-wooded, remain green and alive, or even begin to grow, when placed in the soil. In school gardens or in regions where trees are scarce, or the rainfall is low, it is a good scheme to make special plantations of trees suitable as yam poles. The introduced tree *Cassia siamea* is useful for this purpose, as it is quick-growing, but its poles generally only last for one season.

Teak (*Tectona grandis*) produces good poles for this purpose. If young trees are 'stumped', that is, cut down to within a foot of the base, suckers will develop, and if three or four of these are allowed to remain, good straight poles will be produced in fifteen to eighteen months.

Yam poles should be 12 feet or more in height, and the lower portion should be sharpened and buried at least 2 or 3 feet in the soil, so that later on the poles with their heavy burdens should not be blown over in storms. They should be placed as close to the yams as possible, and at the sides of the hills so as not to interfere with the growing tubers.

The height of yam poles is of considerable importance. From experiments carried out by the Gold Coast Department of Agriculture at Tamale it was proved that the yield from yams supplied with poles 6 feet high was almost double that of yams with poles only 3 feet in height. When poles of 8 feet or higher were used, the yield was only slightly increased.

The young stems often need to be guided in the direction of the poles and they invariably twine round them in a counter-clockwise direction, which is from right to left. The only exception to this rule is the three-leaved yam which twines in the opposite, or clockwise direction, which is from left to right.

The stems grow rapidly in the rainy season and quickly reach the top of the poles. During the rains the yams need little attention beyond weeding between the hills, 'hilling up', and setting up poles which are blown down.

In some districts farmers dig holes beneath the growing yams and refill with loose surface soil. Others simply loosen the soil

beneath the growing tubers with iron bars. These two methods are adopted to loosen the soil so that the tubers may spread more easily through the soil, and therefore grow larger.

In other districts the yams are even 'pruned', the farmer removing the soil from the hill and cutting away small swellings or malformations on the tubers so that they may grow straight and so that one or two large main tubers may be produced. The yam is then hilled up again. In the West Indies there is a type of yam called 'Cut and come again', the tubers of which are partly removed at intervals, after which they grow again.

As the rain slackens off from September onwards the twining stems or 'vines' gradually die. This is a sign that the time for harvesting the yams has come. Some yams are harvested earlier than others, but the average growing season for most yams is about eight months. Generally speaking those yams which are harvested latest, or which take longest to grow, have the hardest flesh and keep the longest and are of best quality.

When yams are wanted for the next season the following practice is generally followed. While the vines are still green and fresh the farmer removes the soil from around the tubers and he selects the main ones. (Plate IX *a*.) Most yams produce one or two tubers which are much larger than the rest, and are the portions generally used as food. It is the large portion or portions which the farmer cuts off near the top (Plate IX *b*), leaving the 'crown' or top part of the yam with the green stem attached. The crown is replanted and gradually grows again in the remaining part of the growing season. (Plate IX *c*.) One or more smaller tubers are generally produced by the replanted crown, and these are allowed to grow until the main stem dies. The tubers are then dug up and used as 'seed' yams in the following season, when they are propagated in the way already described.

Storage of Yams. Yams are stored in many different ways, depending upon the customs and practices of the various tribes which grow them. Two of the main precautions followed in storing yams are to keep them dry and away from the soil, and also to protect them from the strong rays of the sun. After the yams have been harvested, all the soil clinging to the tubers is removed, as it encourages the yams to grow and also may harbour disease. The yams are then removed to the yam store. In some districts it consists of a rough shed supported on strong corner-posts and with the floor raised 2 or more feet above the

ground and composed of the rachis of palm-leaves, often wrongly called 'branches'. The walls of the shed are often made of the same material, and the roof generally consists of grass or palm-leaves or other form of thatch. The yams are piled on the floor and air is able to circulate freely through the gaps in the floor and walls, which is a great advantage in helping the yams to withstand deterioration. The main disadvantage of this system is that yams in storage often begin to rot. Rotting is caused by fungus diseases and is spread by contact so that the rot or mould quickly spreads from one yam to another as they are piled close together in heaps. Also each yam does not have equal conditions of drying and the yams at the bottom of the heap generally have too much heat and not enough air, and, as they are usually moister, disease spreads more rapidly through them. Moreover, they tend to sprout earlier and this is a distinct disadvantage when yams are kept for eating.

In the Calabar district yams are harvested in September or October and are hung up to dry for three months. The seed yams are then put into a sheltered place, such as a shed, and are covered with a layer of plantain or other leaves. The upper portion of the yams are placed facing upwards and in January sprouts generally appear. This system is specially adopted to help the yams to sprout, after which they are planted out at the end of January or February.

Probably one of the best ways of storing yams is that followed by the Fantes, Northern Ashantis, and also by the Ibo tribes in Southern Nigeria.

A large framework of poles is first erected, 'living posts' being used for the vertical upright supports which are arranged in two rows very close together, and 7 or more feet high when driven in. Long cross poles are then placed in position and tied to the erect poles with bush fibre. The space left between each pair of erect poles is roughly 2 to 4 feet and 1 to 2 feet between the horizontal poles.

As the yams are brought in from the farm they are carefully cleaned and all soil removed, and they are then tied one by one to the erect poles, beginning at the bottom. Long pieces of fibre are used, and they are looped round each yam and pulled tight so that each yam rests against the upright pole and often against the horizontal pole as well. The yams are generally strung up on both sides of the upright pole in such a way that they are kept slightly apart. The great advantage of this system is that

it prevents the spread of disease from one infected tuber to a healthy one. Another great advantage is that each tuber has practically the same amount of air and the same temperature, so that conditions of storage are much more even and satisfactory. (Plate X *a.*)

The double rows of poles are placed generally 5 or 6 feet apart, so that a farmer with many yams will have a yam store covering a considerable area, with rows or racks of yams which he can walk between and inspect with the greatest of ease. Yams of the same variety are generally stored in the same part of the yam store so that one farmer may have five or six varieties of yams in separate groups in different parts of his store.

Another great advantage of these stores is that the living poles quickly produce shoots at their upper ends and a mass of leaves soon completely shade the yams stored beneath, and the poles are not attacked by termites or boring insects. The shade from the sun also prevents the tubers from cracking, as easily happens when they are fully exposed to the sun's rays. Even in wet weather the yams easily dry up afterwards because of the diffused sunlight and the wind circulating freely through the racks. (Plate X *b.*)

These yam stores are sometimes made near the farm or on the outskirts of the village, and are often surrounded by a fence which is entered through a special door. The stores are often constructed in the compound itself so that the yams can easily be reached and removed one by one, beginning at the top, and used as food. In Ibo districts the men's and women's yams are kept in different parts of the compound, the men's yams being the larger.

After the yams have been stored for some weeks, and especially in damp weather, they begin to sprout. When stored in heaps the yams at the bottom may have produced sprouts 2 or 3 feet long before they are discovered. In yam racks, however, the sprouts can easily be seen, and the farmer goes round his store every few days, breaking off the sprouts with his fingers, or removing them with a knife. Should rot set in amongst his stored tubers, he cuts away the diseased portions and rubs in wood ash.

Pests. Yams, as a rule, are not much troubled by the diseases and insects which reduce crops of cacao and citrus fruits to such an extent. The main reasons for this are that they are not introduced plants but are native to the country and, therefore,

more resistant to local pests, and also the farmer cultivates them with greater care. The leaves are sometimes attacked by caterpillars or by beetles, which tend to weaken the plant but do not prevent it from forming tubers. By far the most disastrous pest is the yam beetle, which suddenly makes its appearance every few years and disappears as suddenly as it comes. This beetle is almost black, about ½ inch in length, and made its appearance in Southern Nigeria a few years ago, when it wrought great havoc in the yam crop by eating the tubers. These beetles appeared in such numbers that most of the crop, particularly in the Ibo district, was destroyed, and there was great scarcity of food, as yams are the main food crop in that district, as well as in Yoruba country. There appears to be no ready way of destroying them and it is fortunate that such attacks are few and far between.

The same pest appeared recently in Northern Ashanti where Mr. Cotterell recommends hand-picking in the nymphal stage, before the wings are developed, as a control measure.

2. YELLOW YAM

These yams are very similar to white yams in many respects, except that their flesh is yellow. They are of slightly poorer quality and they do not keep quite so long as white yams, which are generally considered the best.

In the growing stage yellow yams are mainly distinguished by their shorter, broader, and more rounded leaves which are more heart-shaped than those of white yams, and much more deeply indented at the top. The leaves of yellow yams are also a much darker green, and they are glossier and have a smoother surface, with the veins in much less distinctly marked grooves than those of white yams.

On the whole the same methods of propagation and general culture is adopted for yellow yams as for white yams. Both white and yellow yams are generally boiled and pounded in mortars into a sticky mass known on the Gold Coast as 'fufu'.

3. WATER YAM or WINGED YAM

[DIOSCOREA ALATA]

This yam is quite distinct from both white and yellow yams in tuber, stem, and leaf. The tubers are generally larger and coarser and are more or less spherical in shape, while white and yellow yams are generally lobed in some way, the main lobes

often being cylindrical. When cut across the flesh of the water-yam tubers is softer and drops of water soon appear on the cut surface, which accounts for the name 'water yam'. In white and yellow yams the flesh is much firmer and more compact, and for these reasons these yams keep longer than water yams.

The outside skin or 'bark' of the water yam is generally darker than that of other yams, and if a small portion of it is removed with the finger-nail, a bright yellow or bright purple layer is sometimes seen between the outside skin and the white flesh. These coloured layers sometimes help in identifying certain varieties of water yams.

Water yams will generally grow on poorer soil and under drier conditions than white and yellow yams, although large crops can be grown when water yams are planted in rich soil with a good rainfall.

The tubers are propagated in a slightly different manner from ordinary yams. Small tubers may be cut into two, three, or four pieces, and large tubers into six or eight pieces of about equal size. The soft fleshy inside portion is then scooped out from each section with a sharp knife so that each 'set' to be planted consists of an outside portion or 'skin' and a layer of flesh on the inside 1 to 2 inches thick.

Some farmers prefer to let their 'sets' dry for a few hours before planting them.

The land is dug and hills prepared in much the same way as for ordinary yams, and the sets are planted in the centre of the hill and near ground-level. On the dark portion or skin the buds or eyes arise and they soon grow into new plants.

The growing-points of water yams are often bright purple, and as they appear above the ground it will be noticed that the stems are not thorny but have curious 'wings' upon them. The winged appearance of the stems of water yams accounts for their other common name of 'winged yams'.

The leaves of water yams are quite distinctive. The petiole or leaf-stalk is generally winged and the leaf itself is larger and broader than that of either the white or the yellow yam. It is rounded in outline and is heart-shaped, with the veins in furrows.

Water yams climb round the poles from right to left in the same manner as ordinary yams, and some varieties produce flowers. The flowers of all yams are interesting because the spikes of the male and the female flowers are produced on

separate short stalks in the axils of the leaves. The female flowers give rise to three-winged fruits, each containing one small winged seed.

Some varieties of water yams produce small bulbils in the axils of their leaves. (Fig. 14.)

Water yams are generally not beaten into 'fufu', but are cut into portions, boiled, and eaten whole. They are of poorer quality than either white or yellow yams.

4. THREE-LEAVED YAM [DIOSCOREA DUMETORUM]

This yam is easily distinguished from all other yams by its leaves being compound, consisting of three leaflets, the two side leaflets being unequal sided. The stems are prickly and climb in a clockwise direction, or from left to right, in that way being different from the above yams. The tubers are often large and coarse and as they are generally bitter they are not often eaten, except after steeping in water for a day or so to remove the taste.

There are several varieties of this yam which vary in the colour of the flesh, appearance of the tuber, and quality of the flesh.

It is not grown on any large scale as a rule, and is eaten by some tribes more than by others.

5. CHINESE YAM [DIOSCOREA ESCULENTA]

This yam is mainly distinguished by its method of producing a great number of comparatively small yams in a hill, each yam being separate, though attached to others and to the main aerial stem by strong wiry stalks. (Fig. 15*a*.)

The aerial portion, or main stem, is not so leafy or so strong in growth as that of other yams. The leaves are small, pale green, and broadly heart-shaped.

This yam thrives in drier and more open districts than either the white or the yellow yam. It is propagated by transplanting a whole tuber in each hill in an upright position, when small buds or shoots will appear near the apex of the tuber.

At the end of the season each hill will be found to contain fifteen or twenty or more tubers about the same size as the 'seed' tuber originally planted. Each tuber is produced in a more or less oblique position and when the soil is loosened all the tubers can be removed in a bunch by shaking the soil off them. Each tuber is covered with a pale brownish yellow and

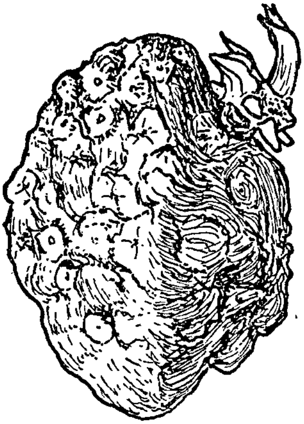

Fig. 14

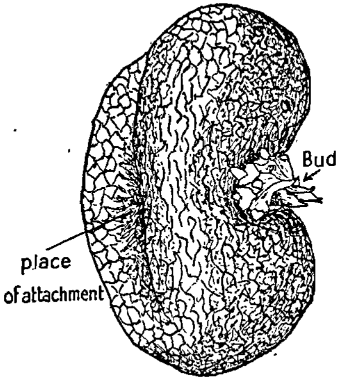

Fig. 15*b*

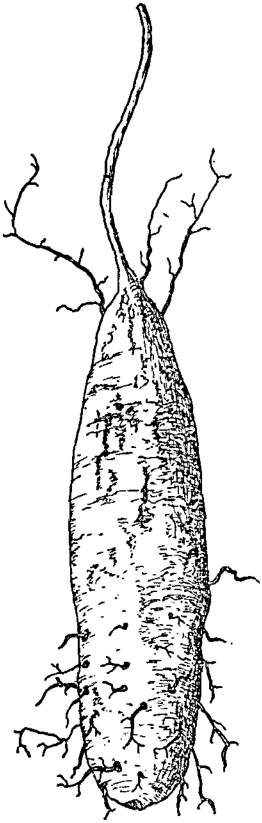

Fig. 15*a*

Fig. 14. Aerial bulbil of water yam.

Fig. 15. (*a*) Tuber of Chinese yam. (*Dioscorea esculenta*). (*b*) Corky bulbil of bulbil-bearing yam.

rather smooth skin, and the shape is almost cylindrical, and 4 to 8 inches long, as a rule, depending upon the season, district, and soil conditions.

Chinese yams resemble sweet potatoes in many ways, especi-

ally when boiled, as they have a rather sweet flavour akin to that of the sweet potato. Chinese yams are only grown in limited districts and generally by particular tribes, such as the Ewes in Togoland and the Fantes in the Abura district, but they could be much more widely grown in open grassy districts with a rainfall of 30 to 45 inches.

6. BULBIL-BEARING YAM [Dioscorea bulbifera]

The main characteristic of this yam is the habit it has of producing curious swellings in the axils of the leaves which grow to a general appearance like that of yams produced underground. These swellings are in reality swollen buds produced in the axils of the leaves which become enlarged owing to the storage in them of reserve food, mainly in the form of starch. Such growths are called 'bulbils' and may reach a diameter of 3 or 4 inches. (Fig. 15 *b*.) The stem of this yam turns from left to right.

There is a wild yam which commonly produces small bulbils with a silvery white colour and a thin skin. Such bulbils are generally only about 1 to 1½ inches in diameter and are said to be poisonous.

In some districts special bulbil-bearing yams are grown on farms and the bulbils reach a greater size than the wild poisonous ones. Their skins are also darker and thicker than that of the wild one, and may sometimes be quite thick and corky, so that it is almost impossible to penetrate them with the finger-nail. This thick layer is to prevent the flesh of the bulbil from drying up in the strong sun and winds to which it is exposed by its aerial position. If left undisturbed these aerial bulbils finally fall to the ground, where they produce buds or 'eyes' on their surface and special roots, and then, using up the reserve food in the bulbil, these new shoots are able to give rise to new plants, which in their turn produce bulbils.

These large bulbils produced by the cultivated varieties on farms are of various shapes and sizes. They can be kept in storage for a considerable time due to the thick skins with which they are provided. There are two or more kinds of such yam bulbils which are definitely edible.

They are propagated by planting the bulbils whole, or by cutting them into two or more portions, each of which generally has the power of shooting out buds.

In another type of bulbil-bearing yam the stems are smooth and the leaves large, broad, and heart-shaped. They are pale green and have deeply furrowed veins. These leaves resemble those of ordinary water yams in many respects, except that they are slightly smaller, have no winged petioles, and the tip is extended into a long and slightly twisted point.

CHAPTER XV

COCO-YAM. SWEET POTATO. TIGER-NUT

OLD COCO-YAM [Colocasia antiquorum]

Eddo (*West Indies*). **Koko** (*Gold Coast* and *Yoruba*).

This is a tuberous plant, growing to a height of 6 feet in suitable soil. It has large pale green leaves, the leaf-stalks of which are joined to a point towards *the centre* of the leaf itself. (Fig. 16 *a*.) This peltate characteristic, as it is called, and the pale green colour of its leaves, distinguish it from the other coco-yam (*Xanthosoma sagittifolium*. See Fig. 16 *b*.) The flowers are rarely seen.

It is a native of India, but it has been grown in Egypt for many centuries, so that it is probably from Egypt that it was introduced, in the distant past, to West Africa. Certainly there is no record of its having been introduced by the Portuguese, as were so many other food plants.

It has been in cultivation for many generations and it is only gradually being replaced by the *Xanthosoma* coco-yam, which was introduced into the Gold Coast nearly one hundred years ago. *Colocasia* is the coco-yam most commonly seen in Southern Nigeria. On the Gold Coast it is seen only in the more out-of-the-way parts of Ashanti, where it is chiefly grown by the older men and women.

The Ibos plant it round their villages and in special plantations, whereas round Benin and in many parts of Yoruba country it is planted in small groups in the villages. In Ashanti it is often grown in shady low-lying places, such as beside streams or in fresh-water swamps. There are at least two common varieties, one with green and the other with purple leaf-stalks.

The swollen underground portion is in reality a form of underground stem known as a corm. It is almost round in cross-section, up to 6 inches in diameter, and consists of one main corm in the centre with smaller ones, like buds, growing round the outside. All are covered with a brown fibrous husk, which is removed with a knife before cooking. In propagating these coco-yams the small corms or 'cormels' are generally used. If the larger corms are used they are usually cut into two or more pieces. In certain Ibo districts these cut portions are first placed in a heap of vegetable rubbish or compost in the corner

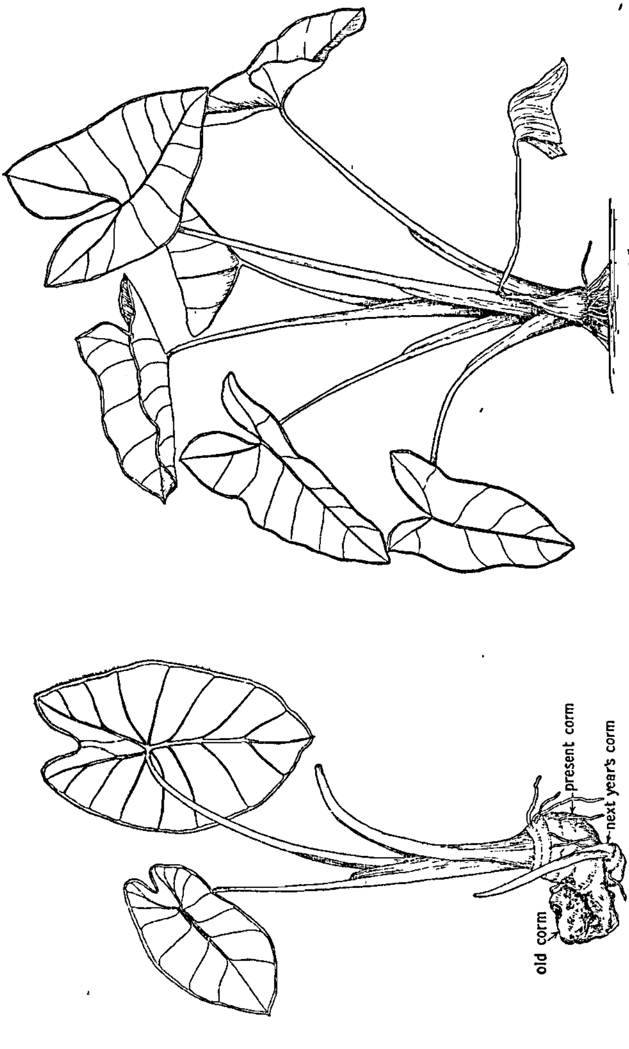

FIG. 16 *a*

FIG. 16 *b*

FIG. 16. (*a*) *Colocasia* coco-yam. Note peltate leaves. (*b*) *Xanthosoma* coco-yam. Note sagittate leaves.

of the compound, and, after they have grown, they are transferred to the farm in wet weather.

After removing the husk with a knife, and before cooking, the flesh, which is very white, is generally soaked for some hours to remove a poisonous juice which it contains, after which the pieces are boiled, and they turn slightly yellow in colour after boiling. They require much more boiling than *Xanthosoma*, but when boiled they are softer, and in the Gold Coast they are eaten chiefly by old men and women who are toothless, and who find them easier to eat. As they become so soft they are quite unsuitable for pounding into 'fufu'. In the Gold Coast they are sometimes mashed and mixed with palm oil before eating.

The central portion of the stem at the base of the leaves is also white and is sometimes cooked and used as food. The young leaves can be cooked and eaten as spinach. The fully grown leaves and stalks are used in other parts of the tropics as food for cattle and pigs.

Starch can also be obtained from the underground portions (for method of preparing coco-yam starch see *Xanthosoma*).

NEW COCO-YAM. TANIA [XANTHOSOMA SAGITTIFOLIUM]

A large plant from 4 to 6 feet in height with large arrow-shaped leaves, which are triangular in outline and dark green in colour. (Fig. 16 *b*.) The leaf-stalk is joined to the leaf at its lower end, and not towards the centre as in *Colocasia*. It seldom produces flowers, except occasionally in the wetter parts of the Closed Forest country. (Figs. 17 *a*, *b*.)

The large, starchy, underground portion is in reality a form of underground stem known as a corm.

This plant was introduced to the Gold Coast from the West Indies by Basel missionaries in 1843, and has gradually spread throughout the forest and trans-Volta country and was taken back to Ashanti after the Ashanti-Quittah war. It has practically replaced the *Colocasia* coco-yam in such districts. In Nigeria, however, *Xanthosoma* is most common near Lagos, and it is gradually spreading throughout Southern Nigeria, where it will probably gradually replace the much more common *Colocasia*. In Sierra Leone *Xanthosoma* is the type of coco-yam chiefly grown by the Creoles of the Peninsula, while both kinds are grown in the Protectorate.

There are several varieties which differ mainly in the size of the foliage and corms, in the colour of the leaf-stalks and the

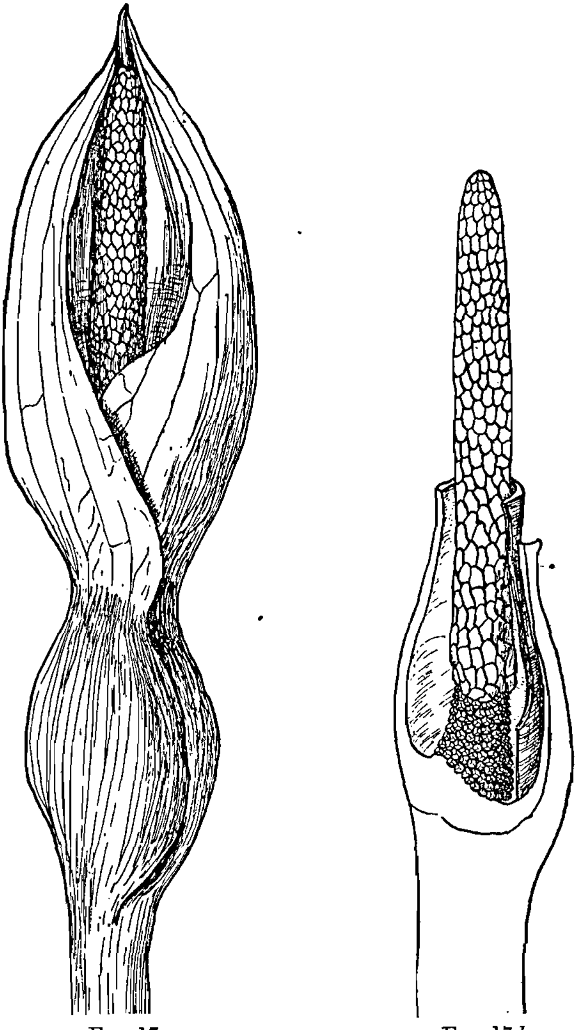

FIG. 17 *a* FIG. 17 *b*

FIG. 17. (*a*) Flower (spathe) of *Xanthosoma* coco-yam. (*b*) *Xanthosoma* coco-yam flower opened up showing female flowers round the base of the spadix.

flesh of the corms, the prominence of the veins on the leaves, and the shape of the cormels.

The propagation of the coco-yam is both complicated and interesting. It is propagated from pieces of 'seed' which are in reality pieces of the underground stems of coco-yams from old coco-yam farms. Each contains a few buds attached to the main portion, and these are generally planted about 3 feet apart. The portion planted grows rapidly and produces a large corm at the base of the leaf-stalks and below the piece of underground stem originally planted. Around the sides of this main corm, smaller corms or 'cormels' appear, eight to ten being the average number of cormels produced. (Plate XI *a.*) They are flask-shaped, that is broader at the outside ends, and generally 6 to 9 inches in length. These cormels are the portions usually used as food, and when they are mature the leaves generally turn yellow. If they are not harvested at this period, they generally start growth again and become watery and not so suitable for food. They are usually ready for harvesting twelve to eighteen months after the original planting.

Sometimes the larger and uppermost cormels are removed before the plant is mature to induce the plant to produce new cormels.

At the time of harvest, the cormels are removed, the leaves are cut off, and the corm is trimmed down with a cutlass and then replanted. This old corm, which is to form 'seed' for the next generation, continues to grow and produces an entirely different system of growth from the first generation of corms with flask-shaped cormels. It increases in size and forms a rough-shaped rhizome with roots on its lower surface and new round or oval-shaped growths on its lower surface. (Plate XI *b.*) These are smaller than the cormels produced by the previous generation. These are eventually dug up and the old rhizome is again trimmed with a cutlass and planted again, the whole process continuing for several generations, until the quality of the coco-yams becomes poorer, after which they are allowed to grow wild and the farm goes 'back to bush'.

Coco-yams form an excellent cover crop, their large cool leaves giving off abundant water vapour, which provides the shade and the moist atmosphere which the young cacao trees require. The use of coco-yams in this way partly accounts for their rapid spread in the cacao-growing districts of the Gold Coast. When the old coco-yam farm has been shaded by growing trees or by

the 'bush' which has been allowed to grow up again, it suffers accordingly and the leaves and underground stems gradually diminish in size. If they are thoroughly smothered by luxuriant vegetation they may disappear from view for years, but when the same land is cleared and burnt over again in the preparing of new farm land, coco-yams often reappear, growing from the remains of their underground portions, which have been lying dormant for years. As soon as they once more have the conditions necessary for their growth, they soon produce large-sized and healthy plants again, bearing corms which are once more fit for food.

The cormels or off-shoots of the main corm are the portions of the coco-yam mainly used as food. In some varieties the white portion in the centre of the stem above ground is eaten.

The delicate young leaves of the coco-yam (*Xanthosoma*) are eaten as spinach and are rather slimy when cooked, but serve as an excellent food, being rich in vitamins and mineral salts.

The cormels themselves are first peeled to remove the fibrous husk and are then boiled, after which they are pounded in a mortar into a sticky mass known as coco-yam 'fufu'. This is the main starchy food in many parts of the forest country of the Gold Coast, although in certain parts of Ashanti some of the chiefs still refuse to eat it for superstitious reasons. Its use is slowly spreading to certain forest districts of Southern Nigeria. In the Gold Coast the spread of this coco-yam has largely followed the spread in the cultivation of cacao, as *Xanthosoma* coco-yam has been used so widely as a cover crop for young cacao trees.

In the Calabar district the Efiks sometimes roast these coco-yams in the fire with their skins on. When fully roasted they are removed, the skins peeled off, and the starchy portion eaten.

These coco-yams are susceptible to a certain disease which causes the underground portions to rot, the leaves to turn yellow and wilt, and the whole plant to putrefy. This disease is quite recent and has appeared in the Gold Coast, where it is spreading through the main coco-yam districts of the forest country. So far the disease has been found to be caused by a fungus related to the fungus causing 'damping off' of seedlings. Very little is known as yet of the conditions which favour the attack and spread of the disease, one theory being that the cause is a lack of potash in the soil.

Coco-yam Starch

Coco-yam starch is prepared in much the same way as cassava starch, and is dried in the sun, broken up into a dry powder and stored until ready for use. It will keep well for many months. The fibrous substance left in the bags or cloths is of little food value but can be fed to pigs.

THE SWEET POTATO [IPOMOEA BATATAS]

The origin of the sweet-potato plant is not known with certainty. It has been found growing wild in the forests of Malay. When the Spaniards discovered Central and South America in the fifteenth and sixteenth centuries they found sweet potatoes being grown by the Indians there, so that it is probable that the sweet potato was of American origin. The Spaniards introduced it to Europe, and it was used in England in Shakespeare's time, before the common 'Irish' potato was introduced into England from North America by Sir Walter Raleigh.

The sweet potato has been spread all over the world by the Spanish, Portuguese, Dutch, and British explorers and is now grown extensively in most tropical and sub-tropical countries. In the Southern States of America it is one of the main food-plants of the Southern negro.

In West Africa it is grown to a large extent by some tribes, while amongst other tribes it is scarcely used.

There are in the United States and the West Indies many varieties of sweet potato, which can be divided into three main groups:

(1) Those with dry and mealy flesh when cooked.
(2) Those with soft and watery flesh which is sweet when cooked.
(3) Large coarse varieties which are eaten by animals only.

The watery-fleshed varieties are known in America as 'yams', chiefly because of the resemblance of the tubers to those of true yams, but the name is confusing and should not be used in West Africa, where there are so many true yams. In this part of the world very few varieties occur, but new American or other varieties could be, or have been introduced and have done well to begin with, and their sweeter flesh is much appreciated. Introduced varieties soon become coarser, however, and to keep the quality high it is best to keep introducing new stock from abroad.

The few common West African varieties are mainly distinguished by the colour of their leaf-stalks or petioles, and by the unlobed, slightly, or deeply lobed leaves.

The variety with deeply lobed leaves produces white tubers which are edible, and are the sweetest and take longest to mature, while the variety with undivided heart-shaped leaves produces red-skinned tubers with cream-coloured flesh which is of good quality as food. One variety sometimes produces purple bell-shaped flowers like those of the Morning Glory, to which family the sweet potato belongs. In some parts of the world sweet potatoes even produce seeds, but this is rare, and such seeds are generally used in growing new varieties.

Soil Requirements

The sweet potato is a sun-loving plant and does not do so well when grown in a shady position. It grows best in a light soil or in loam. It will even grow in sand, provided that it gets enough water. It will grow in regions of fairly low rainfall, but does best in districts with a rainfall of between 30 and 50 inches per annum. It does well in a loamy soil where there is good drainage and plenty of humus present. Weeds and grass should be buried when the soil is being prepared, and the deeper the soil is dug first the larger the tubers will grow in the loose rich soil. It is good to manure the soil with farmyard manure, but if too much manure is added the leaves grow too luxuriantly in proportion to the growth of the tubers.

Clay soil is quite unsuitable for sweet potatoes, and in low-lying swampy districts the yields are generally small. If the soil is at all inclined to be flooded at any time in the rains, it is best to plant the potatoes on raised mounds of some sort so that the surplus water may drain away, and the tubers may be kept well above the water-level where there is better drainage and more air. Various types of mounds are prepared, depending largely upon the custom in different districts. In Northern Nigeria and the Northern Territorities of the Gold Coast, large flat-topped mounds are made. These vary in size and are square or rectangular in shape, with an area of 16 or more square feet to each mound, and drainage channels between the mounds. In other parts the mounds are small, round-topped, and close together, and a single plant is planted on the top of each. A common method is to raise the soil in ridges or rows 2 or 3 feet or more apart with corresponding furrows between the ridges

to help in the drainage of water. This practice is probably the commonest system of planting used on the Gold Coast.

Where the soil is 'light' or somewhat sandy, and the rainfall low, it is better to plant sweet potatoes 'on the flat', or in other words no mounds should be raised.

Propagation

Sweet potatoes can be propagated in three ways, namely by (1) tubers, (2) slips, and (3) soft-wood cuttings.

A sweet potato tuber is in reality an underground stem and therefore is able to produce buds. If a potato tuber is planted, therefore, new plants will grow from its surface, using up the reserve starchy food in the tubers in producing a luxuriant growth of new plants which, in their turn, produce new sweet potatoes. Even if a tuber is cut into two or more pieces and each piece planted separately, each section will give rise to new plants. This method of planting whole tubers, or portions of them, is somewhat wasteful and is not recommended for general use.

The second method, namely planting by slips, is more practicable. Tubers are planted in a nursery bed and covered with a layer of sand 3 to 6 inches thick and kept watered continually. They quickly produce new plants all over their surface, each new plant having complete stem, leaves, and roots. These can be broken off with the fingers at the surface of the potato, and each small plant is called a 'slip'. These slips can be planted out on mounds in wet weather and grow rapidly, as they have their own roots.

The third and commonest method is that of planting 'soft-wood cuttings'. These consist of the soft green stems pulled from a partly or fully grown plant. Those taken from fully grown plants are best, and the older the piece of stem is taken the better. If it has roots attached it will transplant well, otherwise the soft stem will soon produce new roots when it is buried in soft, moist soil. If the stems taken are too young and green, they sometimes die when transplanted, especially if the soil is too dry, or if the sun is too hot soon after they are put into the soil. The older end of the stem is buried in the damp soil, which is firmly pressed round it. At least half the length of the stem is buried in this way, and new roots soon appear along its length. The older leaves on such soft-wood cuttings generally wither and die, but the young leaves near the growing-point soon develop as soon as the new plant is firmly rooted.

The growing period of the sweet potato in West Africa varies from three to four months. The creeping stems rapidly cover the ground, and, although a certain amount of weeding and cultivation is needed in the early stages, the mass of stems and foliage quickly smothers most of the weeds so that any plants which grow above the sweet potato can quickly be seen and removed by hand. The ridges or mounds should be kept mounded up during the growing season, whenever the rain washes them down.

When immature the tubers show a green coloration, but when mature this is not seen.

When harvesting the crop, which is generally done by digging up the tubers with hoes or with large forks, care must be taken not to injure the tubers, as they are very susceptible to disease through such injuries. It is best to dig them up on days when there is no rain, and they can be left lying on the surface of the soil until the evening, if the sun is not too hot, after which they are taken home. In many parts of West Africa sweet potatoes are dug when required as food, so that little attempt is made to store them.

Sweet potatoes are eaten only by certain tribes in West Africa, while other tribes eat them scarcely at all. They are prepared in various ways for food, being often cut into pieces and boiled, or cooked in palm oil. They have a sweet taste and are rich in starch and of much the same food value as yams.

Sweet-potato leaves are eaten by some tribes as spinach.

Besides being of value as human food, sweet potatoes are also of value as food for cattle, goats, and pigs. Certain coarser varieties, as we have seen, can be fed to cattle and other farm animals, while all varieties, and all 'scraps' left after preparing sweet potatoes as human food, are useful for farm live stock.

When sweet potatoes are harvested it is almost impossible to avoid breaking some of the tubers, so that small portions of tubers and sometimes whole tubers are left in the soil. These portions rapidly produce new plants and foliage when rain comes, and become 'weeds' in the midst of the following crop. One way to remove them is to dig up these remaining portions of tubers, but this is often a slow and difficult matter. At Achimota, land which has been growing sweet potatoes is used for pigs, which are 'folded' upon it. That is, the land is enclosed in movable iron fences on wheels, and the pigs, enclosed in such fences, rapidly dig up the sweet potato remains with their

snouts, and 'clean' the land thoroughly of the future 'weeds'. These sweet potato remains are excellent food for the pigs, and as these enrich the soil at the same time with their urine and excreta, it is a satisfactory all-round arrangement. After they have cleared one portion, the movable fences are then used to enclose a new portion and so on, until the pigs have cleared the whole land originally under sweet potatoes. Sweet potatoes are also good food for cattle, but they like good ones, whereas pigs will consent to eat those that are bad.

The foliage of sweet potatoes is also of value for feeding farm stock. The leaves and stalks are good food for cattle, and can be fed to pigs or goats as well. The Kikuyu tribe in East Africa feed their sheep on the growing vines.

Sweet-potato tubers are used in some parts of the world for the manufacture of alcohol. Sweet-potato starch, syrup, and flour can also be prepared from the tubers.

TIGER-NUT. EARTH ALMOND [CYPERUS ESCULENTUS]

This is a grass-like perennial plant, said to be a native of southern Europe, with low-growing tufts of pointed almost triangular leaves. It does not generally produce flowers, but when it does the flowers are at the top of short triangular stems, and are numerous, inconspicuous, and reddish-brown. Beneath the ground it produces small hard round 'nuts' which are in reality tubers of underground stems. It is by these that the plant is propagated, as they readily produce buds and new plants when put into damp soil. If they are soaked before planting, however, they grow more readily.

The tiger-nut plant closely resembles the hated nut-grass (*Cyperus rotundus*) or 'devil grass', a similar plant with small round tubers, which is a troublesome pest in many school gardens and nurseries and which is almost impossible to eradicate. The tiger-nut plant, however, does not produce so many 'nuts' as the nut grass, but it is liable nevertheless to become a weed unless all the 'nuts' are carefully dug out.

The 'nuts' or tubers are spherical in shape and are edible and have a sweet nutty flavour, resembling almonds, hence the name 'ground almonds'. They are generally eaten raw, but contain many fibres which are indigestible and must be removed from the mouth after chewing.

Tiger-nuts are used more as a luxury than as a staple food, and are chewed just as people chew sweets. In some places,

such as at Ada on the Gold Coast, the 'nuts' are dried in the sun, roasted to remove all traces of moisture, then pounded in a mortar and ground on a stone to a fine powder, or removed from the mortar and sieved to remove the coarser fibres until a fine powder is obtained. The white or yellow varieties are preferred for this purpose. Water is added to the powder and after sugar and salt have been added also, according to taste, the liquid is drunk.

Sometimes roasted corn is added to the dried tiger-nut and both are ground together on a stone. The resulting starchy powder has water added to it, and salt and sugar as well, and the mixture is then eaten like porridge.

In some districts, however, the fresh tubers are pounded and 'tiger-nut milk' is prepared from them in the following way. The tubers are pounded in a mortar, put into a piece of clean white cloth and soaked in warm water, and the 'milk' is squeezed out with the fingers. This 'milk' is then put into a pot on the fire and stirred to prevent it forming lumps. It becomes gradually more sticky, and sugar is sometimes added according to taste. The resulting sticky mass is eaten with a spoon like porridge. It soon ferments and should be used within twenty-four hours.

Tiger-nuts are grown in a few parts of the sub-tropics and even in West Africa its cultivation is restricted to certain tribes and districts only. The crop grows well in sandy loam soil with a medium or light rainfall and thrives along the coastal plains of the Gold Coast where it is specially cultivated and one variety with large 'nuts' occurs. It is also grown by the Hausas of Northern Nigeria.

The tubers are rich in both carbohydrates (sugar and starch) and in oil, and air-dried tubers have been analysed and found to contain 43 per cent. of carbohydrates, 28 per cent. of fatty substances, and 15 per cent. of fibre.

(Cf. Holland, *Useful Plants of Nigeria*, p. 761.)

CHAPTER XVI

COTTON

THERE are several species of the cotton plant which are fo[illegible] in various parts of the tropics, so that its actual origin is uncertain. In West Africa the cotton plant has been grown for many generations by Africans, who had spun, dyed, and woven it into cloth long before Europeans came to the country.

Generally speaking, the American, Egyptian, and other introduced cottons have long fibres and are greatly preferred by manufacturers, whereas the indigenous African cottons are short fibred and for that reason are of little use for export, although they are largely used in the African cotton industry carried on in so many districts and villages in West Africa.

Of the introduced varieties American Sea Island cotton has the longest fibres, but it is not hardy and has never proved successful in West Africa. Some varieties of the 'upland' types of American cotton, which have shorter fibres than those of Sea Island cotton have been successfully introduced into West Africa. Of these American cottons, belonging mainly to the species known as *Gossypium hirsutum*, one variety known as Allen has been most successful. This variety does best in Northern Nigeria, where it is the type usually grown for export. It seems to suffer less from the dry conditions and from attacks of insects known as jassids than Ishan and other varieties of cotton. The native varieties are generally of greater height than the American varieties and in this way they resemble Egyptian cotton.

In Nigeria, where scientific work on cotton is so much in advance of that of the Gold Coast and Sierra Leone, considerable success has been attained by the development of local strains. One of these is known as Meko cotton, a variety of *Gossypium peruvianum*, with shorter staple than the American Allen type. It derives its name of Meko from the place of that name in the south-west of the Abeokuta province of Southern Nigeria, from which it originally came, and it is typical of much of the local cotton grown in Southern Nigeria.

It had been known for some time that other types of cotton with longer lint occurred in other parts of Southern Nigeria, and in 1923 the Economic Botanist of the Nigerian Agricultural Department went to the Ishan district of the Benin

province and brought back to Ibadan selected seed from some of the long-fibred plants which he found there. From this selected seed the well-known type, known as Ishan cotton, was developed by selection and cultivation. Ishan cotton, which belongs to the species known as *Gossypium vitifolium* (Figs. 18 *a*, *b*, *c*), produces not only a longer fibre, but fibre of a silkier and better quality than that of the average native-grown Southern Nigerian cotton (*Gossypium peruvianum*) of which Meko is the best type.

On the Gold Coast, cotton is of relatively less importance, although during the last few years the Agricultural Department have paid attention to the development of the best local varieties, as well as growing sample plots of introduced cottons, particularly Allen. In British Togoland there is a small cotton industry which the Government is trying to encourage, and trials have been made with a local Ewe variety of cotton known as Sonko which, however, has not done so well as Nigerian Ishan cotton in field trials. In the Northern Territories greater efforts have been made to develop a cotton industry in the Tamale district, so far with little success. Three strains of American type of cotton have been suggested for development, Ishan cotton having proved unsuccessful, and one Dagomba variety, known as Ganvelga, has been the only local variety specially mentioned as being suited for further development.

In Sierra Leone, although cotton is widely grown for local use, especially by the Mendes, very little has been done so far to develop an export cotton industry. A variety with a khaki-coloured lint is grown by the Mendes, as well as white-linted varieties, and khaki-linted cottons are also grown by Africans in other parts of West Africa.

The method of flowering of the cotton plant is interesting. The flowers are pale yellow, generally with dark centres, and open in the morning, pollination taking place during the day, and the flowers turning pink or red within twenty-four hours, after which they wither and die. In the selection and cultivation of the cotton plant on Agricultural Experimental Stations in West Africa, every effort is made to prevent cross pollination of the flowers, as in that way plants of poor quality cross with those producing cotton of good quality, so that the quality of the resulting crop is lowered. 'Selfing' therefore is practised by the plant breeder, that is, each flower is tied up with a piece of string as near as possible to the time it opens so that each flower pollinates itself, and if the flowers of the best plants are first

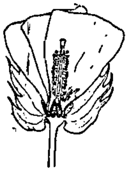

Fig. 18 *a*

Fig. 18 *b*

Fig. 18 *c*

Fig. 18. (*a*) Cross-section of cotton flower. (*b*) Fruit (boll) before and after bursting, showing locks of cotton in which seeds are embedded. (*c*) Ishan Cotton. Diagram of plant in flower.

selected the quality of the resulting cotton may be improved. The improved Nigerian Ishan cotton was treated in this way before the seeds were distributed, and in the improvement of any other local African variety careful selection and 'selfing' of the flowers would be necessary.

The cotton plant thrives in many parts of West Africa and could be grown far more widely than it is if other export crops were less profitable. When the world price for cotton is low the short-linted West African cottons are hardly worth selling.

Probably climate is even more important in successful cotton growing than soil. Cotton does best in those districts which have a distinct wet season, during which the plant can produce most of its growth, and a distinct dry season, during which the crop reaches maturity.

It is an exhausting crop and does best on a rich soil, and will do well in clay-loam soils, provided that the clay is not so stiff that cracks are formed in the dry season, as this injures the roots. Cotton does not thrive so well in soils that are too sandy, but does best in rich deep loams and clay-loam soils. It is a sun-loving crop and does best in the open with a well-distributed rainfall. Too heavy rainfall, especially in the flowering season, not only encourages too much vegetative growth in lighter soils, and actual waterlogging in heavier soils, but encourages the development of cotton pests, notably the boll-worm, which will be mentioned later.

Cotton will grow in districts with a rainfall as low as 20 inches, provided that the soil is suitable and the rainfall well distributed. The main cotton-growing districts in West Africa, however, have a rainfall of between 35 and 50 inches, and the success of the cotton crop is largely dependent on the proper distribution of this rainfall. The main cotton-growing district in Nigeria is in the Western Province of Southern Nigeria, where comparatively small amounts are exported and the main part of the crop is grown for local cloth-making and dyeing among the Yoruba people, as it has been for generations. Most of the cotton grown in this district has short lint, although it is strong, and has a brownish tinge. Its colour and short length make it of small value for export purposes, although it is acceptable to Yoruba spinners.

Cotton is generally sown in July, and in parts of Southern Nigeria it is shaded for the first weeks of its growth by the ripening maize, amongst which it is planted. Its main growth

takes place during the rains of August to October, and it generally flowers after the end of the rains, that is in October, November, and December. In Northern Nigeria most of the cotton is harvested before the end of January, but in the South the cotton is not harvested until March or April, during which time the cotton plants afford shade to the growing yams.

Although cotton is not an annual plant it is generally treated as such, for if it is allowed to last into a second season or longer, the diseases and pests are carried over into the following year. Cotton is generally grown commercially on a large scale and therefore the soil is usually but roughly prepared, in spite of the fact that it is a crop which responds well to thorough and deep preparation of the soil.

The seeds should be sown three to four in a hill at distances of 3 to 5 feet apart, according to the variety grown and the nature of the soil. It is advisable to set them in rows, and the plants should be thinned out later if necessary. The highest yields are obtained when cotton is grown alone, but the common practice in Southern Nigeria is to grow cotton among food crops, notably amongst yams or corn. From experiments conducted it was found that the growing of cotton under such mixed cultivation lowered the yield of the cotton per acre by at least 30 per cent. In spite of this lower yield, the cotton grown under mixed cultivation was found to be freer from cotton pests, as when cotton is grown in pure stands insect pests and diseases can spread more quickly from one plant to another. It is therefore vitally important that any new variety of cotton introduced to the Southern Provinces should be able to do well under mixed cultivation. The improved Ishan cotton does much better than the American Allen under mixed cultivation, which is one of the main reasons why Allen cotton has been unsuccessful in Southern Nigeria.

During the growth of the crop it is important to keep the ground thoroughly weeded and tilled, especially in its early stages. If the season is at all dry, the thorough cultivation of the surface soil prevents too great a loss of soil moisture, and the cotton plant, having a deep tap-root, seeks its water at greater depths in the soil. Because of its deep rooting-system it can remain green even in the dry season, and after the cotton is picked, at which time its leaves are sometimes eaten by cattle and goats.

The cotton plant seems to be particularly liable to insect and

fungoid attacks. In some seasons many of the flower-buds are attacked and fall, or dry up owing to unsuitable weather. As the crop comes into full flower its pests gradually appear. Probably the best known of these pests is the Cotton Stainer, a small reddish insect which attacks the opening bolls, leaving a bright green stain which reduces the commercial value of the lint. Cotton stainers are difficult to get rid of, and constant hand-picking of them as they appear seems to be the best practical method known so far. Stainers cause more trouble on late-sown cotton, so that their attacks can be partly avoided by early sowing. Where late-sown cotton is grown near early-sown cotton the late cotton is liable to attack by the first generation of stainers from the adjacent early cotton. The improved native varieties, such as Ishan and Meko, appear to be less troubled by stainers than the introduced American Allen variety. Stainers cause less trouble in the 'harmattan' season, as the weather becomes exceedingly dry.

Probably the next worst insect pest of cotton in West Africa is the boll-worm. Although the term 'boll-worm' is singular, there are in fact more than one 'worm' or caterpillar that attacks cotton bolls. These caterpillars are the larval form of certain moths, and the caterpillars eat their way into the cotton bolls in search of the developing seeds. The bolls are thus damaged and finally fall to the ground before reaching maturity. The female moth lays her eggs singly during the night on the terminal buds, young stems, and bolls, but the larvae themselves eventually attack the bolls, although they often eat into and destroy some of the flower-buds too. The control methods for dealing with this pest are difficult to suggest, hand-picking of infested bolls appearing to be the best method known so far.

A disease, known as anthracnose, produces complete rotting of the cotton bolls and is probably aided in its spread by insects. Its attacks also seem to be more severe under certain climatic conditions, such as a sudden setting in of the 'harmattan'.

The minor pests of cotton, such as leaf-curl and others, are dealt with more fully in the yearly bulletins of the Nigerian Agricultural Department.

Cotton should mature in the dry season and the bolls generally burst in January or February, although in some districts they burst earlier, and the cotton hangs out of the 'locks' of the fruit for several days. It is picked by hand into large loose bags or baskets slung over the shoulder. In picking care should be

taken to keep the cotton as free as possible from impurities, such as portions of the fruit, dried leaves, or stained cotton.

The cotton is brought to the cotton ginnery and after being thoroughly dried in the sun, and stained cotton and other impurities removed, it is put into the gin. The gin is the machine used to remove the cotton or 'lint', as it is called, from the cotton seed, to which the fibres are attached. There are two main types of gins, one known as the roller gin, into which the cotton is fed between two rollers, and the other as the saw gin, in which the lint is removed from the seed by an arrangement like saws inside the gin. Gins vary in size and the amount of seed-cotton that they can take. In large central places in cotton districts power gins driven by engines are used, but smaller gins driven by turning a large handle are sometimes seen. Care should be taken to adjust the saw or rollers of the gin so that the maximum amount of lint can be removed without injury to either seed or lint.

As the lint is both light and bulky, some method of compressing it before transporting it to the coast must be carried out. Hand compression is impossible, so that special machines known as baling machines are used. These are either operated by power or by hand, and in them the lint is compressed into a very much smaller volume and is finally bound with iron bands. (Plate XIV *b*.) The weight of a standard bale is 400 lb., and it is sold to merchants, who export it to Europe, where it is manufactured into various cotton articles.

In the past the cotton seed, after separation from the cotton lint in the gin, was thrown away, until scientists suggested that, if ground up, it could be applied to the soil as a manure. Since then it has been found to be rich in oil, 20 to 22 per cent. of the seed being removed as oil by crushing.

Before the seeds can be crushed, the 'fuzz' or 'linters', consisting of the small particles of cotton fibres still attached to the seed, must be removed. These 'linters' are removed by machinery and are a useful source of cellulose and are becoming increasingly important commercially in the manufacture of paper and artificial silk.

Cotton-seed oil is yellow in colour and is often used as a substitute for the more expensive olive oil as a salad oil. It is also used in the manufacture of margarine, after it has been somewhat refined, and is used also to some extent in the making of soap. The residue remaining after the oil has been pressed out

is rich in proteins and carbohydrates and also still contains a small percentage of oil, and when compressed into cakes is used, under the commercial name of 'cotton-seed cake', in the feeding of cattle in the same way as coconut and palm-kernel cakes.

An effort to make cotton-seed cake was made at Ibadan, but because of the excess of woolly seed the cake was found to be unsuitable for cattle food and was therefore used as fuel in driving the ginning machinery.

So far only the commercial and export value of cotton has been mentioned, but the cotton plant has been used for many generations among certain West African tribes, long before cotton ever became an export crop in West Africa. The wild and undeveloped short-stapled cottons were, and are, used for this purpose, and the plant is either grown under mixed cultivation on the food farms, intercropped with maize, yams, or other food crops, on the outskirts of the villages. Little attention is paid to the plant until the bolls burst. Then the cotton is picked and brought back to the village, where the lint is removed from the seed by hand. (Plate XII *a.*) Stained lint and other impurities are also picked out and the lint is then subjected to a process known as 'combing', hand-made or imported combs being used. (Plate XII *b.*) In this combing or 'carding' process the fibres are carefully combed out straight and parallel to each other, the lint being moved several times and recombed before it is finally removed and laid into neat rolls in a flat basket on the ground. The combing process then gives place to the spinning process. The neat rolls of lint are first rolled on to a large bobbin, each roll being roughly attached to the next one by adhesion. (Plate XIII *a.*) The actual spinning is done by hand, the spinner carefully removing the rolls from the large bobbin with one hand, teasing the cotton out between the two hands from a very thick to a thin strand. (Plate XIII *b.*) During this teasing-out process the thread is spun by means of another much smaller bobbin, shaped rather like a small top, with a thin pointed portion below. This bobbin is placed on some smooth cup-shaped article on the ground at the spinner's side. A broken piece of shell of the large edible snail is often used, and the spinner keeps the small bobbin constantly revolving by means of a deft twist of the fingers every few seconds. This revolving motion of the bobbin is transferred to the cotton fibres, which are carefully pulled out between the fingers of both hands until they are of uniform thickness, and as thin a thread as possible, combined with as great a strength as

can be obtained for a thread of such thinness. A coarse spun thread is the result, and it is wound on to the smaller bobbin on the ground, after which it is wound off on to the larger bobbins which are set aside for weaving.

The home-spun West African thread is comparatively thick, coarse, and somewhat uneven. This is to be expected as the spinning motion instead of being supplied by rapid revolutions of power machinery, as in the Lancashire mills, is only supplied by continual twists of the hand. Also, as the length of staple of African cottons is shorter than those used in proper cotton factories, the thread cannot be pulled out so fine, and is consequently thicker. Nevertheless, the fibre of native African cotton is said to be stronger than improved cottons such as American cottons.

The weaving of cotton by native looms is too large a subject to be dealt with in a book of this size, and is described more fully in books dealing with the life and industries of the various tribes. There are various kinds of hand-looms used by the different tribes (Plate XIV *a*), the Mende loom and the Yoruba loom being two of the best-known types.

The thread is often dyed in various ways before it is woven, or in some cases the cloth is dyed after it is made.

The commonest dye used is indigo, a blue dye obtained generally from the Yoruba or West African indigo plant (*Lonchocarpus cyanescens*), which is used widely by the Yorubas and by the Ewes of Togoland. Amongst the Hausas of Northern Nigeria and in the Northern Territories of the Gold Coast, plants belonging to the genus *Indigofera* are generally used, and are grown on the spot, the *Lonchocarpus* dye being an imported article from the South. The preparation of the indigo dye is also a specialized business which can be studied elsewhere. Locally grown indigo is used by many West African tribes, especially among the Yorubas of Southern Nigeria where it is the prevailing colour of the garments of both men and women.

Certain designs in blue cloths are sometimes obtained by tying up the cloth in various ways with string before putting it into the dye pits. Ingenious patterns are often obtained in this way, in which certain parts of the cloth are lightly or deeply dyed in the indigo, and these markings may be in circles or stripes or other designs, depending upon the way in which the cloth was tied before it was dyed.

A red dye, obtained from camwood (*Baphia nitida*) or fro other trees such as *Pterocarpus Soyauxii* is sometimes used dyeing cloth, and makes it a rich red colour. Yellow, green, an black dyes are sometimes used, some of the processes in the manufacture being trade secrets among the special Africa classes or families who prepare them.

The imported Anatta dye plant is used, as in some Mende districts, in the preparation of a reddish dye used in the dyeing of home-spun cotton cloths.

Sometimes the natural khaki-coloured cotton is used and the Mendes of Sierra Leone who grow it and use it specially, work it artistically into their blue-and-white cloths.

Home-spun or woven cotton cloths are generally either white or blue and white, the blue being usually arranged in stripes, but some weavers make cloths of more intricate design, and when khaki, red, black, green, or yellow colours are also introduced, some wonderfully coloured and designed African cloths are produced.

Even with the primitive looms at present in use a far greater range of cloths of more varied designs and colours could be made, whereas with improved looms or hand-looms of an introduced type, cloths could be made with still more wonderful and varied designs and of much wider strips.

The home-spun and woven cloths are generally much thicker and stronger than imported cotton cloths, the famous 'Kano cloth', for example, making excellent clothes which will outlast most imported cotton materials.

With the increased importing of cheaper and more brightly esigned manufactured cotton material the home-made cotton loths are unfortunately rapidly disappearing. The first stages the decay of the home spinning and weaving industry are seen the use of imported dyes and threads, which are so much sier to prepare. These imported threads, often dyed with ported dyes, or bought already dyed from Europe, are some- 1es woven into cloths of African design. The famous Quittah ths of the Gold Coast are of this type and are growing poorer uality year by year in texture, dye, and design, until now possible to buy cheap imitations of Quittah cloths made ngland.

lthough it is more or less natural that imported cotton 1s should take the place of local cloths for ordinary every- wear in modern West Africa, yet it would be a great loss

indeed if the arts of cotton spinning, dyeing, and weaving to die out altogether. Much can be done in encouraging industries in schools, either as a hobby or as a special trade. by improved methods of weaving, and the introductio looms capable of making broader strips, home weavin African cloth could be brought more up to date, as it is b developed in many homes and schools in Europe to-day.

CHAPTER XVII

CACAO (THEOBROMA CACAO)

CACAO is a small tree, native of Central America, and growing generally to a height of 20 to 30 feet. It forms three to five main branches at a few feet from the ground.

The flowers are numerous and small and are produced on the trunk and main branches at the place where a leaf formerly existed. These places are known as 'cushions', and although several flowers may grow on one cushion, only one or two, or more rarely three, develop fruits.

There are several varieties of cacao, such as Criollo, Cundeamor, and Forastero which includes Amelonado. Of these we only consider two, namely Criollo and Amelonado.

Criollo

This variety is of American origin and is the kind most usually grown in Trinidad and the plantations of Central America. It is grown very little in the Gold Coast and is usually found only on Agricultural Stations. The tree grows smaller than Amelonado, is not so hardy, and is much more susceptible to the attacks of insect and fungoid pests.

It produces beans of a finer quality, better texture, superior flavour and aroma, and therefore is used in the manufacture of the higher grades of chocolate.

There are two kinds of Criollo, red and yellow, the pods of which are similar in shape and differ only in colour. Criollo trees have been known to produce both red and yellow fruits, but as a general rule a tree produces pods of one type only. The fruit is generally pointed (Fig. 19 *a*) and the seeds are plump and round, the interior colour being a pale pink to deep rose.

Amelonado

Amelonado is one of the varieties of Forastero cacao and the kind most widely grown in West Africa. The fruit is ovoid in shape (Fig. 19 *b*) and more round than Criollo, and generally golden yellow in colour. The furrows are slight and the surface comparatively smooth. There is a slight constriction near the neck and the point is blunt. The wall is fairly thick and inclined to be woody, while the seeds are flattened and the interior colouring is pale to deep purple.

Cacao thrives best in deep, well-drained soils, preferably heavy loam or light clay. Our finest cacao farms are found in those localities where deep red clayey loam abounds. It has a deep tap-root and therefore does not do well in shallow soils or stony hill-sides. Also if grown in cold, wet soils, the roots

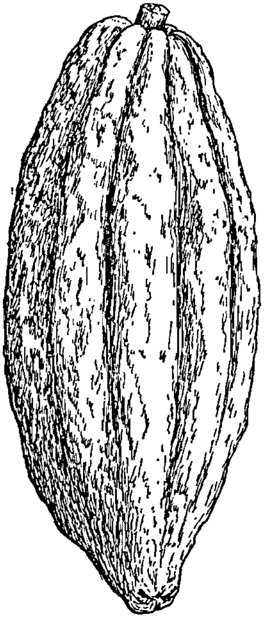

FIG. 19 *a*

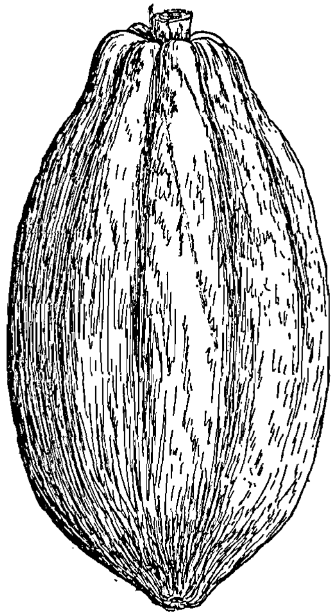

FIG. 19 *b*

FIG. 19. (*a*) Pod of Criollo cacao. (*b*) Pod of Amelonado cacao.

become waterlogged or drowned. Gently sloping, well-drained river valleys sheltered from the wind, are best for cacao plantations. Cacao has never proved successful in the Delta region of Eastern Nigeria owing, it is believed, to the acid condition of the soil.

Cacao is sensitive to strong winds, and therefore should not be grown too near the coast, unless protected by a windbreak, or unless the situation is sheltered. Generally it does not thrive at altitudes over 2,000 feet.

It thrives in a warm humid climate, and for this reason must

be protected from hot drying winds. Young trees need some shade from the sun, but well-established trees can thrive even without shade, if protected from strong winds.

Cacao is best grown in nurseries. The best pods from the healthiest and most prolific trees should be chosen. Only the best beans should be selected, and after being washed they should be placed in a shaded but airy place to dry. It is better to keep them a few days before planting, as this helps them to germinate more quickly when planted.

Cacao seedlings, like bean seedlings, bring their two cotyledons above the soil. In a few months they are 1 foot high and should then be carefully transplanted with a ball of soil around their roots. Only the sturdiest plants with fully developed leaves at the growing-point should be selected, as plants with soft growth at the apex soon wilt and seldom survive.

In West African farms most cacao trees are planted too close, 6 to 7 feet apart being a usual distance. The disadvantages of such close planting are

(1) Too great competition amongst the plants for the plant-food in the soil.

(2) Too great competition amongst the branches and leaves for the available light.

(3) The trees grow too high and 'spindly' so that fewer pods are produced and they are found higher up on the branches, where they are more difficult to harvest.

(4) Insect pests and disease can spread rapidly from tree to tree, especially as there is too little air and sunlight.

The trees should therefore be planted at a distance of 15 to 18 feet apart both ways wherever possible. On hill-sides they may be planted slightly closer together. Large deep holes should be prepared, and the subsoil at the bottom should be well stirred to facilitate easy rooting. Only surface soil should be used to refill the hole, and the soil should be well pressed about the roots. The transplanting should only be done in wet weather, as young cacao trees are easily killed by drought.

On many farms the trees are gradually dying, the young branches dying back in the dry weather through lack of shelter. Methods of prevention and cure are:

(1) Shelter belts of trees or individual trees should be left when land is being cleared for a cacao plantation. These belts afford shade, and also shelter from storms and drying winds.

(2) When possible special shade trees should be planted before the young cacao. trees are transplanted. Any quick-growing trees will do, provided that they give plenty of shade and are not easily blown over in tornadoes. Leguminous trees producing shade and plenty of foliage, which will benefit the plantation by the continual shedding of leaves are suitable. The rain tree and *Gliricidia* (Madre, or 'Mother of Cacao') and *Erythrina*, which is used in Trinidad, are three of the best. Amongst local trees *Parkia* and the oil bean tree (*Pentaclethra*) are both suitable. Such shade trees should be planted not nearer than 50 or 60 feet apart. The oil palm is quite a useful local tree which is suitable.

Plantains, bananas, or coco-yams are often planted between the young trees, to shade them in the early delicate stages and also the soil between the young trees is made use of by taking a crop from it. Also the ground is kept free from weeds and loss of surface soil during heavy rains is prevented. As the trees grow the bananas, plantains, or coco-yams planted between them should be gradually removed, beginning with those situated nearest to the young cacao trees.

The trees soon form between three and five main branches at a few feet from the ground.

If the young plant produces more than one main stem at the beginning, the surplus shoots should be removed. It should always be remembered that the tree produces the greater part of its crop on its trunk or on its three or four main branches. (Plate XV.) All extra or weak shoots, therefore, should be removed. After the main branches have been produced all other upward extensions of the main stem and suckers of shoots near the base of the tree should be pruned, preferably at the time of harvesting the pods.

Many cacao trees produce their first flowers when three years old. These should be rubbed off with the fingers and not allowed to bear fruit, as that would weaken the tree. After five years most cacao trees begin to bear and they are in full bearing from seven to ten years and afterwards. After twenty years or so they gradually begin to decline, although so gradually that trees of 80 or 100 years old, still bearing fruit, are known in other parts of the world.

Harvesting generally takes place from September to December, which is the main cacao season. There is a 'small' cacao season from April to June.

Ripe pods can generally be distinguished not so much by their colour as by tapping them, when a fully ripe pod sounds hollow. The pods must be cut from the tree with a sharp instrument, such as sécateurs, a knife, or a cutlass, while for those pods out of reach a hooked knife attached to a pole is required. Great care should be taken not to injure the 'cushions' on which the pods grow, as new flowers, and therefore fruits of future years are produced on these cushions.

Unripe pods should never be picked; over-ripe pods, or pods containing seeds which have already germinated should always be picked but must not be used with good pods for fermentation, as beans from such pods hinder proper fermentation and result in beans of poorer quality. Constant harvesting as the pods ripen is the only practice to be recommended.

The pods are piled in heaps and left for three or four days, after which it is easier to remove the contents. (Plate XVI.) The pods are then broken either with a cutlass or by knocking the pods against each other, or against a stone. The beans and the surrounding mucilaginous material are removed with the fingers and put directly into baskets or placed in heaps on banana or plantain leaves spread on the ground.

The African farmer generally ferments his beans on the spot by piling them in large heaps, covering them with banana leaves, and leaving for four to six days, with occasional turning.

For the best results the beans should be fermented in boxes, generally made of Odum (Iroko), and they should be specially protected from rain. Boxes 5 feet long, 3 feet 6 inches wide, and 3 feet deep should be sufficiently large for crops from 10 to 12 acres, three boxes arranged one above the other being generally used. The fresh beans are placed in the top box, covered with banana leaves and a board or other heavy weight, and left for two days. The temperature rises and fermentation takes place.

After two days the weights and the banana leaves are removed and the beans are thoroughly stirred with a wooden shovel (Plate XVII *a*) while being transferred through the trap-door in the side of the first box into the second or lower box. Here they are covered again and left to ferment for another two days, after which they are uncovered and mixed up once more before being emptied into the third box. The beans remain covered up and fermented in the third box for another period of two days. The process of fermentation is then completed.

During fermentation the seed changes from violet to reddish

brown within, and from white to yellowish-brown on the outside.

The sticky pulp surrounding the fresh seeds is white and sweet to the taste, but in fermentation it quickly changes to a dirty brown colour and liquifies, the whole giving off a strong odour of vinegar. The sugar in the pulp is quickly fermented to alcohol and finally to acetic acid (vinegar). Most of the pulp after liquifying escapes through holes in the bottom of the boxes.

The main advantage of this way of fermentation over the usual method of fermenting in heaps covered with banana leaves is that the beans remain at a more or less even temperature all the time. In the heaps the outside beans are not properly fermented while those in the centre of the heap undergo excessive heat and may be over-fermented while those at the bottom sometimes actually germinate. In the box all beans stand an equal chance of fermentation as they are stirred three times during the six days when they are moved from one box into the next. This stirring and mixing prevents germination, lowers the temperature suddenly, and prevents it from rising too high as it does when the beans are left undisturbed for five or six days. The beans quickly reach the same constant temperature when removed into a new box.

If seeds from a ripe cacao pod are eaten raw they have a bitter taste, while properly fermented seeds have a very different taste. The bitter and unpleasant taste has disappeared and the bean tastes much sweeter and more like true cocoa or chocolate. Such beans bring a higher price.

The main reasons for fermenting cacao therefore are as follows:

(1) To convert the bitter taste of the beans into a sweet one.
(2) To give cocoa its characteristic odour by releasing an essential oil.
(3) To release and form the substance known as theobromine, which gives cocoa its stimulating property.
(4) To make the 'nibs' more friable and of better texture and to loosen the seed-coat or skin (compare the skin of a dried unfermented bean with that of a fermented bean).

One disadvantage liable to arise from fermentation is that fermented beans are more likely to be attacked by moulds

than unfermented beans unless they are well dried. Some European cocoa manufacturers would rather have well-dried, doubtfully fermented beans, than well-fermented, doubtfully dried ones; all would naturally rather have well-dried and properly fermented beans.

After removing the beans from the third fermenting box they should be thinly spread out in a light airy place to dry. There are several methods adopted. (Plate XVII *b.*) Some farmers lay the beans on the ground, either on sheets of corrugated iron or on waterproof sheets. The main disadvantages of these methods is that the beans need to be constantly turned and can only be dried on one side at a time. Furthermore they are exposed to filth and contamination from domestic animals. Drying the beans on iron sheets is not to be recommended, as the acidity acting on the metal causes a discoloration of the beans, which consequently bring a poorer price when sold.

The best method, which is now widely used, is to dry the beans on mats which are raised on poles 2 to 4 feet from the ground. These mats are generally made from split pieces of bamboo or from the split midribs of the leaves of the oil or Raphia palms, preferably the latter. Spaces are left between the slats or pieces which are tied together with a bush creeper. In this way the air can reach the beans from beneath also and the beans require less turning and dry quicker.

The beans should not be dried too rapidly at first or they will shrivel. They should be shaded at midday on the first and second days. On the third day and after they can be left as long as the sun is out. After six or eight days or more, according to the amount of sunlight, the beans should be thoroughly dry. It is possible to tell when this stage is reached as they give a crackling sound when rubbed in the hand and powder easily. Well-dried fermented beans are chocolate coloured and taste like unsweetened chocolate. Unfermented beans are slaty in colour, have little taste of chocolate, and are not easily powdered in the hand.

On no account should the beans be allowed to become wet. On the approach of rain they should be taken indoors or covered with a waterproof sheet.

Before bagging the dry beans all pod fragments, placentas, stones, and bad beans should be removed by hand.

Beans must not be bagged while hot or until they are properly dry, as they 'sweat' in the bags and will develop

moulds. Cacao that has been prepared in the 'small season' always tends to be attacked by moulds more than 'main season' cacao, which is often stored in the dry season. Mouldy cacao is a great source of trouble to chocolate manufacturers for various reasons, but mainly because of the unpleasant flavour which these moulds impart to the produce.

Bagged beans must be kept in a dry, well-ventilated store and air space should be left between the floor and the bags. Dry cacao, however, is able to reabsorb water from the atmosphere in humid districts, even when stored indoors. Therefore when properly dry, *cacao beans should be sold and transhipped* as quickly as possible. Weevils (small boring beetles) and moths [illegible] red too long.

CHAPTER XVIII

COFFEE. COLA

COFFEE

There are several species and varieties of coffee grown in various parts of the world, and most of them are of African origin, having occurred wild in the forests of tropical Africa. The main varieties are as follows: *Arabica*, *Stenophylla*, *Liberica*, *Robusta*, and *Excelsa*.

Arabica, or Arabian coffee, produces one of the best quality coffees. It is a native of the mountains of Abyssinia and was carried from there to Arabia and later to other parts of the world. Arabian coffee has small leaves and small fruit and was grown largely on estates in Ceylon until a blight or fungus disease caused the death of most of the trees. As it is not so robust and is less able to resist disease, Arabian coffee is seldom grown in West Africa. Also it is an upland coffee, that is, it needs a mountainous climate, and, as most of West Africa is under 2,000 feet high, it is seldom planted there. It is, however, grown in the highlands of East Africa.

Stenophylla, or Sierra Leone upland coffee, is also a small-leaved species, but is hardier than *Arabica*. It will also thrive at lower altitudes, and, in spite of its name, will grow well in regions under 2,000 feet in altitude. It produces small fruits and seeds which yield a good quality of coffee.

Liberica. This kind of coffee, often known as Liberian coffee, because of its country of origin, is most widely grown in West Africa. (Plate XVIII.) Its leaves are larger than those of *Arabica* and *Stenophylla* and are dark green and shiny. Great numbers of beautiful sweet-scented white flowers are produced in the axils of the leaves, as they are in other kinds of coffee. The fruits of Liberian coffee are also much larger and have a thick husk. Liberian coffee has the advantage of being much hardier than most other kinds and it resists disease better. It will also grow at lower altitudes and can be grown almost at sea-level in parts of West Africa. The quality of coffee produced by this plant is poorer than that yielded by other kinds.

Robusta. *Robusta* coffee is sometimes known as Congo coffee, and it resembles *Liberica* in many respects. It has large leaves which differ from those of *Liberica* mainly in their wavy margins and in the deep furrows in which the lateral veins lie. (Plate

XIX.) The leaves are also very shiny and of a paler green colour than those of Liberian coffee. The fruits are smaller than Liberian, but larger than those of Arabian and *Stenophylla* coffee. They produce a better quality of coffee than *Liberica*. *Robusta* coffee is hardy, as its name implies, and is becoming more popular in West Africa.

The unusual feature about *Robusta* coffee is its early fruiting tendency, and because of this it is largely used as a catch crop between permanent crops during the first five years of their establishment. Good plants of *Robusta* coffee, when properly planted, will fruit in from twenty to twenty-four months.

Excelsa. *Excelsa* coffee is a kind very similar to *Robusta* in general appearance and is also West African in origin.

These various kinds of coffee differ in minor respects, as we have seen, but are almost the same in their habit of growth and general appearance and soil requirements.

The coffee plant is really a small tree and would quickly grow to a height of 30 feet or more if left undisturbed. It is generally pruned to the shape of a low shrub of 4 to 8 feet, however, so that the berries can be harvested easily by hand. Otherwise ladders would be necessary, which would greatly increase the cost of picking the fruits, as well as the labour of reaching them.

Coffee plants are generally started under shade in nursery beds. Seeds should be selected from the richest and finest fruits and from the healthiest plants, and should be sown when fresh. The seeds are slow to germinate and usually take several weeks to start into growth. If plants are to be established in pots, it is a good plan to raise the seeds in beds and to transfer seedlings to pots just when the fourth leaf is fully formed. When good soil is used such plants will make rapid progress and when transferred with care show no ill effects from the move. Otherwise seeds may be sown in pots in the usual way.

The coffee plant has a long tap-root and great care should be taken when transplanting it. When the plants in pots have been 'hardened off' by gradually placing them in more exposed positions, they can be transplanted to permanent positions.

The site for a coffee plantation should be carefully chosen. The soil should not be too stiff or clayey in texture, nor should the rocks be too near the surface, otherwise the deep tap-roots are disturbed and the plants will not thrive. Coffee likes a rich, well-drained, loamy soil or on hill-sides that are not too steep, and should be planted in sheltered positions, as strong winds

blow down the fruits and injure the shrubs. It is often advisable to plant shelter belts of trees at intervals in coffee plantations. Any trees producing thick foliage are suitable, as they break the main force of the wind.

Before the potted plants are put in their final positions holes should be dug 9 to 12 feet apart, depending upon the richness of the soil. The subsoil should be scattered and the holes left open for some time, as the sun and air cause weathering, which improves the subsoil within the holes, converting it to the state when it can be utilized as plant food. The holes should be 2 feet wide and 2 feet deep if possible. Before planting the holes should be filled with good soil, preferably with soil to which humus or manure of some kind has been added. It is often good to add the weeds which have been cut down on the land, as they quickly rot inside the hole and add food to the soil.

To make sure that the soil will adhere to the roots in a compact mass, the potted plants should be thoroughly watered the evening before they are transplanted. The bamboo pot in which a plant is grown is broken by two sharp blows with a cutlass, one on each side of the pot, after which the plant can be easily removed with the mass of damp soil round its roots, and then planted in the centre of the hole. A certain amount of watering in the cool part of the day is often necessary afterwards, and in sunny weather the plants should be protected by small branches of trees stuck into the soil round about, so that the leaves shade the coffee plants.

During the first year or two intercropping with vegetables or other food plants is often an advantage, as it makes use of the soil in between and keeps it free from weeds, and the crops serve to some extent in shading the young growing coffee plants.

After two years or more the young plants should be 'topped'; the tops should be cut off at a height of 4 or 5 feet. Afterwards they should be kept pruned to this height.

After two to five years the plants come into bearing. The fruits or 'berries' should be picked when ripe and carried in baskets to the farm sheds.

There are two main ways in which coffee is prepared for market, the Dry and the Wet Methods.

The Dry Method

The 'berries' or fruits picked from the trees when ripe are dried in the sun on mats composed of split bamboo or of the split

rachis of the *Raphia* or oil palm. After several weeks of sunny weather, when the fruits are properly dried, they are ready for 'hulling', that is removing the husk or thick outside coat. Hulling is generally done on African farms by pounding the fruits in a mortar, when the husks are broken and are separated later from the seeds by a process known as 'winnowing'. The simplest form of hand-winnowing is done by throwing up the broken fruits in a flat pan, when the heavy seeds will fall back into the pan and the husks will be gradually blown away by the wind.

On more up-to-date farms the dried fruits are put through a machine known as a 'huller'. This consists of a small and inexpensive machine like a meat-mincing machine. The fruits are put into the machine and the handle is turned by hand and the dried fruits are crushed against the side of the machine. The hulls are broken and they are thrown out of a hole at the other end of the machine, together with the seeds.

The distance between the central 'screw' of the machine and the sides can be adjusted to suit the varying sizes of the fruits of different varieties of coffee. The space is made wider for large fruits, such as those of *Liberica*, and narrower for such fruits as *Stenophylla*.

The hulled fruits are then put through a machine known as a 'winnower'. It consists of a large wheel with four broad wood paddles on it, so that when the wheel is turned by hand the paddles create a strong draught. As the hulled fruits are dropped down a narrow groove they come in contact with the draught, which blows the lighter husks through the end of the machine on to the ground and allows the heavier seeds to fall on to a screen from which they are afterwards collected into a bag.

The coffee seeds, or 'nibs' as they are sometimes called, are then ready for shipment to Europe. They are flattened on one side and curved on the other, with a groove down the flattened side.

In Europe they are slowly and carefully roasted and are then ground into a powder which is sold as the coffee which we all know. In parts of West Africa people roast their coffee at home and grind it afterwards for their own use.

Coffee beans prepared by the dry process are supposed to be of better quality than those prepared by the wet process.

The Wet Method

The bulk of plantation coffee is prepared by this process, as it is quicker. The fruits are picked when ripe and then put through

wooden rollers loosely set so as to bruise all fruits passing through.

Fermenting is done in large, deep, concrete bins. The beans are then washed to remove all pulp, drained, and then dried, either in the sun or by artificial means.

On small West African farms the ripe fruits are generally beaten in a mortar and allowed to ferment so that the husks become partly rotten, after which the seeds can be removed more easily.

In *Liberica* coffee, which is the variety most usually grown in West Africa, the husk is thick, so that four or five days are generally allowed for proper fermentation to take place. The husks should be properly bruised so that, when wrapped in banana leaves in boxes and allowed to ferment, the thick husks become rotten. The fermented berries are then taken to a river or stream, soaked in water, and then seeds are crushed out with the hands. The soft and rotten husks are then removed, and as the fruits are constantly rinsed in the water the light and empty husks can be gradually floated off and the heavier seeds remain at the bottom. After all the husks have been removed, the seeds, which are enclosed in a thick layer of 'parchment', are washed thoroughly.

Should some of the berries not have been pounded properly, fermentation does not take place in them and the seeds, when removed from the berries, have a slimy and mucilaginous layer round the parchment which cannot be removed by the washing process, or even by ordinary soaking. This layer of mucilage is removed in the wet process, during the four or five days of fermentation, just as the mucilaginous layer round the cacao bean was removed in the fermenting boxes.

During the fermentation the bacteria act on the sweet slimy layer which loses its sticky nature and becomes a thinner liquid which is easily removed in the washing process. Therefore great care should be taken that each berry is properly bruised so that fermentation takes place evenly. Then the husks can be removed in the water easily and the parchment coffee is left without any layer of mucilage around it which may delay its further drying.

The seeds are then thoroughly dried in the sun until they feel crisp and dry.

Coffee in this stage is called 'parchment coffee'.

After being dried thoroughly for a few days it is then pounded in a mortar, and the parchment is broken and winnowed away

in pans on a day when there is sufficient wind. If the parchment is not thoroughly dry it is much more difficult to remove.

Coffee is sometimes sold or exported in the 'parchment' stage, and the parchment is quickly removed by machinery after the arrival of the coffee in Europe or America.

Beneath the parchment is another thin layer known as the 'silver skin'. This is much more closely attached to the seeds and is generally removed finally in the roasting process.

Home Preparation of Coffee—Roasting and Grinding

After the removal of the parchment the beans are now known commercially as 'nibs' and are ready for the final process.

In parts of West Africa beans are sometimes roasted in open iron pots, or in frying-pans, when they are kept stirred constantly until they are of a uniform dark brown colour. Although coffee can be roasted quite efficiently in this way, it is much better to roast it in an enclosed receptacle, such as a proper coffee-roaster. These are small and quite cheap to buy and have the advantage that the gases given off during the roasting are not allowed to escape into the air, but are retained, so that the flavour is preserved.

An efficient coffee roaster can be made by using a sugar tin, or other tin, through the centre of which an iron rod is fixed, with a handle attached to one end. In the side of the tin a small sliding door can be fixed by any one with a small knowledge of tinsmithing, and the 'roaster' can then be half-filled with coffee nibs, put over an old kerosene tin adapted as a charcoal burner, with a groove at each side at the top into which the central spindle of the roaster can be made to fit. A slow fire of charcoal is started and the roaster is then turned slowly for twenty minutes. The constant turning keeps the beans in continual motion, so that they can be roasted evenly. After twenty minutes a strong smell of coffee is noticed and smoke is given off, when it is evident that the nibs are sufficiently roasted. The roaster is removed, the door opened, and the nibs poured out, when they are seen to be of a uniform dark brown colour. Drops of oil are seen on their surface and a strong scent of roasted coffee is given off. This oil is gradually reabsorbed as the nibs cool. If the nibs are bitten with the teeth, they will be seen to be deep brown in colour all through, showing that they have been properly roasted.

Coffee should be ground at the same time as it is roasted, and

should be roasted and ground only when required for use. The grinding can be done easily by a small machine like a meat mincer which can be bought quite cheaply. If such a machine is not available, the roasted nibs can be ground to a fine powder on a smooth clean piece of wood by means of a bottle. When in a finely divided state it is then ready for use, and if made at once into coffee, it has a fine flavour. If it is not used at once it is best to keep it in a dry air-tight tin, for if stored in an open tin it quickly loses its freshness and flavour. If it is not used at once, but is kept in a tin for some time, much of the original odour and flavour can be restored by heating the powder near a fire for a few minutes before making the coffee.

Different varieties of coffee have different flavours, *Arabica* coffee being generally classed as the one of the highest quality.

COLA [COLA ACUMINATA and COLA NITIDA][1]

Cola trees are of medium size, and grow up to 50 feet in height, with dense crowns and branches and leaves almost reaching the ground. The flowers are yellowish-white, sometimes with red stripes; the fruits are produced in clusters, generally of three to five, arranged like the spokes of a wheel. They are covered with a thick, green, wrinkled coat and each fruit contains six to ten seeds or more. The seeds are usually red or pink and occasionally white.

Cola trees are natives of the forests of West Africa and several species grow wild, including the above two species, which are, however, generally cultivated.

Trees of commercial cola can be propagated either by cuttings or by seeds, but the latter method is recommended. Germination is slow and takes from one to four months, and only *fresh* seeds should be sown. As the seedlings have long tap-roots and therefore do not transplant well, it is better to grow them in bamboo pots than to grow them first in a nursery and transplant them afterwards. When the young trees have grown large enough for transplanting they should be moved in wet weather to their permanent positions in the plantation. They

[1] These two species are very similar in appearance in their leaves and flowers. They are distinguished mainly by their seeds. *Cola nitida* has two cotyledons only and is the original Ashanti species, not *originally* found in Nigeria, so far as is known. *Cola acuminata* has more than two cotyledons.

should be spaced at least 30 feet apart. In the early stages it is best to plant a temporary crop which will afford shade for the young trees. Plantains and bananas may be used, not only because of the shade they give, but also because the fruits can be harvested for a year or two until the cola trees are large and strong enough to require less shade.

After four or five years' growth the trees may be expected to bear light crops, but the yield gradually increases afterwards until at ten to twelve years of age the trees are yielding crops of commercial value.

Picking

The main cola season is from October to February during which time the ripe fruits often fall to the ground and should be picked up before they are attacked and bored into by insect larvae. The fruit is generally picked by means of hooked knives on the ends of long poles, as it is difficult to reach the fruits by hand since they, unlike cacao fruits, are produced on the young wood near the tips of the twigs.

The picking knives generally used are similar to those used for plucking cacao pods from high branches. They consist often of a curved knife with the sharp edges on the inside. With these knives the twigs are severed below the fruits which then fall to the ground and are picked up by men below the trees. Sometimes it is necessary to twist the picking knife several times until the fruit comes off the twig.

Cola pickers generally need to climb up cola trees before they can reach the fruits, even with their knives on the ends of long bamboo poles or 'branches' of the raphia palm. As the leaves of the cola tree are often infested with red weaver ants which bind the leaves together to build their nests, those who climb the trees to pick the fruits are generally attacked by the red ants and bitten all over the body in a painful manner. Some cola pickers wrap puttees or cloth round their legs, others rub their bodies over with wood ash which seems to repel the ants to some extent, as they notice the smell of fire in the ashes.

The smaller and darker coloured ants which make small nests on the backs of individual leaves are also found in great numbers on the leaves of cola trees and also attack cola pickers, so that the work of picking cola is made difficult.

When picking cola care should be taken to pick only those fruits which are ripe. When the bright green colour of the fruit

has darkened and is black in places, then the fruit is ready to be picked.

The ripe fruits are picked up from the ground and put in baskets and are either broken under the trees themselves, or taken to a central place where they are broken by a number of people. The fruits are generally broken with cutlasses or sharp knives, but care should be taken not to injure the seeds in the process. When breaking the fruits it is often noticed that the larvae of an insect known as the cola weevil have bored their way through the pod and even into the seeds themselves, leaving a brown and dirty mass of excreta behind. These larvae should be removed, and where they have attacked the seeds the injured portions should be cut out with a sharp knife.

In the process of breaking the pods or fruits several other things are noticed. First, every seed is surrounded by a white pulpy coat. This should be removed with a knife, and if the seeds are properly ripe this coat comes off easily. When the seeds are removed it will be noticed that they vary greatly in size, shape, and colour. They are generally flattened on one or two sides and rounded on the other sides. Most of the seeds are bright red in colour, others are pink, and a few are white. The white seeds, which are much more valuable, are said to be sweeter in taste. Their value is probably due to the fact that they are much rarer than the red ones. They are generally found in the same fruits as the red and pink ones. No tree seems to bear white seeds only, and even if care is taken to plant trees from white nuts, the trees finally produce seeds of all three colours, with red seeds far more numerous and white seeds comparatively rare.

The seeds themselves are easily split into two or three or more pieces. These represent the cotyledons and in most cases only two cotyledons occur. Sometimes three or more cotyledons are found in one seed, in which case the cola is of a different species from that producing seeds having two cotyledons.[1]

When the seeds have been removed they are generally dealt with in one of two ways, depending upon whether they are to be consumed locally, such as in West Africa, or to be exported to Europe or America.

Those that are to be consumed in Africa are sent up north and sold to the Hausas and other northern tribes, and are graded at once. The largest, cleanest and hardest nuts are picked out

[1] Cf. footnote on p. 172.

first and carefully packed in large flat leaves, those of certain Closed Forest *Scitaminaceous* plants such as *Thaumatococcus* and *Clinogyne* being generally used.

These leaves are usually spread on the insides of baskets, with their lower sides turned inwards, and the basket is then filled with cola seeds and covered over with the same leaves again. If cola seeds are packed in this manner for some time they have a tendency to 'sweat' as they give off water in the form of small drops which accumulate on the outside of each seed so that the seeds must be removed and rubbed one by one to prevent them deteriorating in value.

When the seeds are to be kept for some time, therefore, it is necessary that they be first sprinkled with water to keep them cool and moist and therefore fresh. Then they are stored in a cool shady place. The leaves are changed every few days for fresh ones, all nuts that are spoiling are removed, and they are then packed again in fresh leaves. In this form they are conveyed by headload or motor-lorry, from the forest country to the northern and more open districts where they are bought by those northern and generally Mohammedan tribes at a greatly enhanced price.

White nuts, as we have seen, are much more valuable. Any red or white nuts that are too young and soft, or that have been injured by knives or have had to have insect-infested portions cut out are generally kept apart and sold at a much reduced price—usually about half the price of the selected nuts.

Small quantities of nuts are wrapped in leaves and tied round with 'bush' string. They are generally sold in hundreds or multiples of a hundred.

Quantities of cola used to be shipped to Lagos from the Gold Coast but this trade has passed more and more into the hands of Sierra Leone producers. From Lagos large quantities of cola are sent north by rail and then transported to the dry desert regions.

Of late years large cola plantations have been made in Southern Nigeria, particularly in the Agege district near Lagos. Superior varieties were introduced as long as thirty years ago, and the Southern Nigerian cola industry is being developed to such an extent that in a few years it will be unnecessary to import nuts from other West African colonies. This planting of cola in Southern Nigeria is now spreading to the Eastern Province as well. While exports of cola from the Gold Coast to

Lagos have gradually diminished, there has been a steadily increasing trade with the Savannah areas to the north of British territory, and this is likely to increase still further as motor roads and transport are developed.

As cola does not keep long and needs great care before it can be sent even from one part of West Africa to another, it cannot be sent in a fresh state to Europe, as it would not keep fresh long enough. Before it can be exported, therefore, it must be specially treated. One method is to separate the cotyledons and break them into two parts before placing them on racks in the sun to dry, while another method is to separate the cotyledons only before drying. These products are marketed as cola 'quarters' and 'halves' respectively. A later method is to slice the fresh nuts in a special slicing machine. In this way the nuts are cut into fine slices in a much more simple and efficient manner than could be done by hand. The sliced cola is then soaked in water for two or three hours, after which the juice is strained off. This juice is orange in colour, and is the same colour as the sliced cola which rapidly changes from red to dark orange when cut or exposed to the air. The orange-coloured juice is bitter and is thrown away, and the sliced cola is then dried in the sun for many days until all moisture is evaporated. Then it is sifted to remove all dust and small fragments, after which the chips are bagged and are then ready for export.

In Europe and America the prepared cola is ground to a powder and used in the manufacture of certain drinks such as cola champagne, coca-cola, and others. These drinks have a slightly stimulating property due to the drugs present in the cola.

These are caffein, which is also found in coffee, and theobromine, which occurs in cacao. In West Africa the stimulating influence of cola is well known to Africans, who chew cola when on long journeys, and are thereby stimulated so that they can go for long distances without food and with little fatigue. They can also work well all through the day with practically no food or drink by simply chewing cola, which is bitter in taste and which turns bright orange-yellow when kept in the mouth.
Although it acts as a stimulant

CHAPTER XIX

THE OIL PALM. (ELAEIS GUINEENSIS)

THE oil palm is a native of Western Tropical Africa as far south as the Congo. It thrives in the moist climate of the West African forest regions, and does not seem to suffer from proximity to the sea. Where the rainfall is sufficiently heavy it is even found growing along the seashore in Sierra Leone and French Guinea. It is seldom found in the dense evergreen and deciduous forests of West Africa. It seems to thrive best in the forest region between the deciduous forest and open grassy savannah to the south, east, or west of the closed forest. It does not thrive to the north of the closed forest, but always on the south towards the sea. The depth of this oil-palm belt varies from a few miles to fifty miles or more. In such regions the oil palm may be quite common, and is often the dominant tree. (Plate XX *a.*) Sometimes it is so abundant that few other trees are found. In parts of Southern Nigeria the oil palm is the only export crop which appears to thrive on certain types of soil in the Eastern Province. It also occurs in secondary forest and thrives on old farms in forest country.

In West Africa the oil palm is seldom grown specially on plantations as it grows so abundantly in the wild state. In Northern Nigeria it is often specially cultivated in fertile valleys. In the East Indies, however, particularly in Java and Sumatra, the Dutch have a successful plantation system which has gradually been capturing the West African palm-oil trade.

There are several West African varieties[1] of oil palms, each of which has its own name in the various vernaculars. Most of them have a thick shell and are distinguished from each other by the colour and appearance of the fruits.

1. **Dura** (variety MACROSPERMA Welw.) ...
   Nut

2. Variety FATUA Welw.

This variety resembles No. 1, but is not so widespread. The young fruits are green, turning reddish-orange later, or reddish at the base and yellowish at the tip.

The amount of oil in the pericarp is about the same as No. 1. The shells are also thick.

3. Variety SEMIDURA

The fruits of this variety are dark all over. When young they are black becoming dark red at the base and almost black at the tip when mature. The nuts are hard and almost spherical and larger than those of other varieites. It is not so common as Nos. 1 and 2, but produces more oil.

4. Variety ALBESCENS. **White Oil Palm**

'Fruits very large, pericarps reddish-white, occasionally streaked with black; nuts hard; oil of a yellowish colour—yield 15 per cent.' (*Kew Bulletin*, 1909, p. 40). It is quite rare.

5. Variety TENERA. **Thin-shelled Oil Palm**

This variety differs from the preceding ones by having a thin shell which can easily be broken by the teeth. If it is bitten across the pericarp below the seed, numerous fibres can be seen. The bunches are smaller than those of the preceding varieties.

The fruits are entirely red and are smaller and longer than those of varieties 1 and 2, although the bunches are the same size. The pericarp is thick, fibrous, and rich in oil. The nuts are much smaller than those of thick-shelled varieties, are quite round, and are much further away from the base of the fruits.

The young fruits are rich in oil, and are sometimes boiled with salt and chewed.

Because of its high oil content and the ease with which the shells are broken, this variety is recommended as most suitable for special cultivation in West Africa. Thin-shelled fruits have a much higher proportion of pericarp and therefore of oil and fibre, and a lower proportion of shell and kernel than other varieties.

The remaining varieties are of little commercial importance although they are of interest.

6. Variety POISSONII A. Chev. **Perianth-fruited Oil Palm**

This variety is easily distinguished by the peculiar appearance of the fruit which is about 3–4 cm. long, and rather constricted at the base, which is surrounded by a fleshy perianth. This is the name given to the membranous scales round the base of each fruit. In this variety it would appear that the scales, instead of being membranous, are thick, fleshy, and red in colour with black tips. In reality they consist of sterile flowers which, like the pericarp, contain oil.

This variety is rare in West Africa. In the East Indies there is a variety of this kind known as *diwakkawakka*.

7. Variety IDOLATRICA A. Chev. **Sacred or 'King' Oil Palm**

This variety is of botanical interest only, and differs in general appearance from all the other varieties, which differ mainly in their fruits. In the sacred oil palm the leaflets, instead of being at right angles to the rachis, are at an acute angle, so that they appear to be much denser.

Because of its unusual appearance and its rarity, it is regarded as sacred in parts of West Africa. According to Holland it is more common in Nigeria than on the Gold Coast and is commoner along the sandy shores round the sea and lagoons than up country.

The fruits have little commercial value.

In Dahomey their oil is used as 'holy oil' and in African medicine.

As the oil palm is slow-growing and has only recently been carefully studied in West Africa, little is known as yet as to whether seeds of the various varieties will 'breed true' and produce fruit of a similar type in the next and subsequent generations.

The following are improved varieties of oil palms grown in the East Indies:

1. **Deli.** This is the commonest variety grown on plantations. It yields a high percentage of oil and is the variety on which most of the East Indian oil-palm industry is founded. The fruits are larger than the average West African fruit. This variety is said to have originated in West Africa, but so far it has not been found on the Gold Coast. Young trees of this variety are now growing at various Stations on the Gold Coast from seeds introduced from the Dutch East Indies.

2. **Lisombe.** This is a thin-shelled type, similar to the thin-shelled West African variety, and rich in oil.

3. **Mantle** or **Diwakkawakka.** This variety resembles the rare West African perianth-fruited variety. It possesses a mantle round the base of each fruit which, Auchinleck states, consists of sterile, oil-bearing flowers massed round a central fertile fruit. In the mantle type the shell is thick and the kernel small.

The oil palm is propagated by seeds. In Nature the ripe fruits drop to the ground and the natural regeneration of seedlings round the base of the tree is prolific.

Nevertheless, the oil palm is often quite difficult to propagate in the nursery. First, like most palms, it germinates slowly. The fruits, including the pericarp, are planted in nursery beds. They are chosen from high oil-yielding trees and must be sown when thoroughly ripe. First of all the soil is dug deeply, and the fruits planted 3 or 4 inches apart in rows 1 foot to 18 inches apart. The nursery bed is kept well shaded and watered, and in two or three months the seedlings generally appear.

In the East Indies the seeds are first soaked for seven or eight days, the water being warmed to a temperature of between 45 and 50° Cent. (113 to 122° Fah.) three times daily. In Malaya the seeds have been found to germinate well in sand-beds covered with a glass frame, and kept well watered.

Rats and ground-squirrels sometimes dig up and eat the seeds. The only way to prevent this is to cover the beds with fine-mesh chicken wire until all have germinated. Each fruit contains a seed or kernel, but if the seeds or nuts are broken it will be noticed that a few possess two kernels. Occasionally fruits with three, and as many as four kernels are found. The oil palm resembles the coconut palm in that its flower parts are in threes, and there are three holes at the end of the shell. Where three kernels develop, one seedling grows through each hole, but generally only one kernel develops, occupying the space of three, and only one seedling appears through one of the holes, the other two being useless.

After three to six months' growth the young seedlings are sometimes transplanted into bamboo pots or baskets, where they are allowed to recover and grow big enough to plant out into their permanent positions. In large plantations the seedlings are generally allowed to grow for one year or more in the

nursery and are then transplanted in rainy weather to their permanent positions. By this method there is more danger of some of the seedlings dying, as palm seedlings usually transplant badly. All blanks should be filled as soon as possible with new plants. The trees are planted out symmetrically 25 feet by 25 feet and require rich soil with a rainfall of 50 inches or more. They will grow in poorer soil and with less rainfall, but do not give such good results. They generally do well in all districts where cacao thrives.

In the early stages of the plantation the weeds should be kept down as far as possible as they tend to smother the young trees and rob them of food. Clearing the weeds in a circle round the tree, or 'ring weeding' is generally practised. At this stage it is advisable to plant some form of leguminous cover crop to smother the weeds, and to add nitrogen to the soil. *Calopogonium* has been used successfully in parts of West Africa, although such details of oil-palm cultivation are still in the experimental stage in this country.

After three or four years oil palms begin to bear small bunches of fruits, which have little or no value commercially. After five years the trees produce larger bunches which can be harvested, but it is not until they are eight or ten years old that they are producing proper crops, each tree producing from two to twelve bunches of fruit per annum for most of its lifetime. It has been discovered that while with increasing age the number of bunches produced decreases, the weight per bunch increases.

The oil palm produces both male and female flowers. (Figs. 20 *a*, *b*, *c*.) The male flowers consist of tassel-shaped bunches of brown flowers full of golden-yellow pollen. When in flower the tree has a strong scent like aniseed. The male flowers attract large numbers of insects. The tree is cross-pollinated.

In the Dutch East Indies where oil-palm cultivation is more advanced than in West Africa, artificial pollination is carried out. Only pollen from the best-yielding trees is chosen. It is shaken into bags and then shaken over the female inflorescences when the stigmas are ripe. By this method the Dutch have achieved wonderful results in increasing the yield of palm oil from their plantations. Like all artificial methods, however, it is open to abuse, and if carried out too largely it weakens the tree and therefore ultimately the yield of oil. It is too early yet to say to what extent hand-pollination can be carried out so as to give the highest yield of oil without injuring the general

condition of the tree. For these reasons it is being largely discontinued in the meantime.

On some West African plantations all leaves below the bunches of fruit were cut off neatly close to the trunk. The

FIG. 20 *a* FIG. 20 *b* FIG. 20 *c*

FIG. 20. (*a*) Male inflorescence of oil palm. (*b*) Spike of female flowers developing into mature fruit. Note 3 stigmas at top of each fruit. (*c*) Single fruit.

latest method is to remove only dead or damaged leaves, the leaves immediately below the bunches of fruits being removed only as the bunches are harvested.

It has been noticed that most fruits set towards the end of the rainy season, from July to September. In May and June the heavy rainfall probably hinders pollination. The maximum production of fruit appears to be in March, that is from those fruits setting at the end of the previous rains. Ripening of the bunches is hastened by the intervening dry season.

So far few plantations of oil palms have been attempted in West Africa apart from those on Government Agricultural stations, as their establishment is expensive in the earlier stages. West African farmers in oil-palm districts could make a good beginning by taking greater care with wild oil palms, by cutting away undergrowth which is hindering the growth of young palms, and by cutting out old ones and thinning them out where they are too thick. Only good fruiting palms should be retained. When clearing areas for farms care should be taken not to hack off the leaves of palms. If they are thinned out to not more than 25–30 feet apart, such farms, when abandoned, could be turned into more valuable palm areas. Open spaces should be planted with seedlings or seeds from under high-yielding trees. When seeds are planted, eight to ten are put into a hole and thinned out later. If the weeds are kept cleared around these young palms it helps them to become strong and healthy, and considerably higher yields of fruits are obtained from them later.

The difficulties of cutting fruits from wild palms decrease as they are cut more. Old trees over 30 feet high do not respond much to care and cultivation and can be cut out. Younger trees and especially seedlings respond to good treatment. They yield earlier than wild, untended trees, are more easily gathered, and have considerably higher yields. Such renovated young trees can be harvested either from the ground or with ladders for a number of years. Farmers often dislike thinning out palms in their groves when they are too close together. Actually such thinning out generally increases the total yield of the palms in the area within a year or two.

In 'village groves' which consist of special palms growing in the village areas, the yield from each individual tree is generally higher than those in 'bush groves', as those near the village are generally better tended, are not hacked about or burnt, or allowed to revert to bush as are ordinary wild palms.

Although in recent years the West African palm-oil industry has suffered severely from competition from the plantations of the East, the situation is by no means hopeless if West African farmers will improve their methods of cultivation either by making special plantations or by improving their 'bush groves'.

Methods of palm-oil extraction vary slightly in different parts of West Africa, but the general principles are the same.

The African farmer seeing that ripe nuts have begun to fall

to the ground knows that bunches are ready to be picked. Generally only one ripe bunch is ready at a time on one tree.

There are different methods of climbing the tree. In Nigeria and parts of the Gold Coast the farmer raises himself to the top of the tree by a strong loop made of piassava fibres. (Plate XX *b.*) This method is essential when trees are very high. When they are only 10–25 feet high the farmer climbs by means of a ladder made from two strong oil-palm rachis or 'branches' into which rungs are fitted and strengthened and kept in position by tying Rattan palm fibres round. Bamboo ladders are also commonly used.

Before the ripe bunch can be removed, the supporting leaves are cut away level with the trunk. In proper plantations old leaves are kept constantly removed. After the removal of the supporting leaves the stalk supporting the first bunch is cut and the bunch falls to the ground. The ripe bunch is generally left for a few days until the fruits fall out naturally. Sometimes the side stalks are cut from the bunch and the fruits with the short stalks and husks attached are boiled in water, after which the individual fruits can be removed easily.

To prepare the pericarp oil the ripe fruits are first boiled in water to soften the pericarp. They are then either pounded in a tall narrow mortar, or trampled with the feet in a stone-lined or clay-lined pit to loosen the pericarp and fibres from the nuts. The loosened pericarp, fibres, and nuts are then stirred in hot water, and the fibres are picked out and pressed by hand to remove the oil. They are very rich in oil and in the imperfect method of pressing them by hand much of the valuable oil is wasted. They are often treated again with hot water and pressed to remove more oil.

In West Africa the fibres are generally dried in the sun and used later as fire-lighters, the oil in them being very efficient for this purpose.

The fibres are often very small and difficult to remove by hand. The liquid portion of the mass is therefore strained through a basket, or a hand-made sieve, made of tin with holes punched in the bottom. The small fibres are left in the basket and are pressed to remove the oil. The nuts are returned and washed again to remove their remaining fibres.

The whole process of separating first the fibres and then the nuts themselves is slow and laborious. The final product, after straining, is allowed to settle.

This residue left after the fibres have been removed is very rich in both proteins and oil and is used throughout West Africa for the making of palm-oil soup, which is fattening and highly nutritious.

Where there is a large quantity the thick red oil can be skimmed from the surface. Generally, however, the whole yellowish-brown liquid is boiled for several hours to clarify it and remove most of the water present. (Plate XXI *a.*) The resulting product is the palm oil usually classed as 'soft' oil.

If the fruits are buried and allowed to ferment for a few days before the oil is extracted, the resulting oil is said to be a 'hard' oil, and so called because it remains in a solid wax-like condition, even at 90° Fah. The partly fermented fruits are pounded with water and the oil strained, but not boiled.

When palm fruits or palm oil are allowed to ferment certain chemical compounds known commercially as 'free fatty acids' or 'f.f.a.' are formed. If unripe fruits are used, or if oil is prepared by fermenting the fruits first as in the 'hard' oil process, more free fatty acids result and the commercial value of the oil is consequently lowered. If care is taken in the preparation by the 'soft' method, using only fruits which are not over-ripe, oil with very little 'f.f.a.' can be obtained. Soft oil is of more value commercially and is used for margarine manufacture and yields more glycerine than hard oil.

The hard-oil process is generally adopted for export purposes, however, as it is simpler and yields more oil; it is generally carried out by men. Soft oil, which is generally used for local purposes, is usually made by women and produces oil of finer quality.

Palm oil is used in West Africa for palm-oil soup, and as an illuminant in Nigeria and other parts, where it is being gradually replaced by kerosene. African goldsmiths use pericarp oil in their small lamps. It is also used in the making of home-made soap.

The African methods of extracting pericarp oil, however, are laborious and wasteful. Only 5 to 7 per cent. of the total weight of the fruit is extracted as oil in this way, whereas by more advanced methods, such as the use of solvents, 10·5 per cent. may be extracted. Benzene is mostly used, as it dissolves out the oil and can be evaporated again, leaving the pericarp oil behind. The benzene can be condensed and used repeatedly.

In Nigeria experiments have been made to extract pericarp

oil with small hand-presses. These extract more oil and of finer quality than that extracted by hand-methods.

Other advanced methods of extraction are to heat the fruits by steam in special heaters on perforated trays, thus softening the pericarp. It is then put through a depericarping machine which keeps the fruits heated by steam while the pericarp is separated from the kernels. The oil is collected in special receptacles and the fibres are then removed and put into special presses. The remainder of the oil is pressed out, and the fibres are left behind in the form of hard-pressed cakes.

In Europe pericarp oil is used in the manufacture of machine oils, soft soap, candles, and glycerine, and also in the tin-plate industry.

Home-made soap is still largely made in West Africa in spite of the large quantities of 'yellow' soap and carbolic soap imported.

Oil and potash are required in the making of soap. The oil generally used in West Africa is pericarp (palm) oil, although kernel oil, shea-butter, and coconut oil are sometimes used. The 'potash' is obtained in several ways, either from dried cacao pods, plantain, and banana skins which have been burnt to an ash, from the burnt pods of the tree *Afzelia africana*, or the dried and burnt leaves of Physic Nut bush (*Jatropha Curcas*). Ashes from burnt cacao pods or plantain skins are most generally used and are first soaked in water. This dissolves out some of the mineral salts in the ashes, such as sodium chloride (common salt), sodium nitrate, potassium nitrate, potassium chloride, potassium sulphate, and other mineral salts consisting of inorganic compounds of magnesium and calcium (cf. Chapter III). The soaked ashes are then strained through a cloth and allowed to settle, and the top liquid which has changed from a greyish colour to a dirty reddish-brown, owing to the settling of the grey powder, is then poured into a pot. Palm oil is added to the liquid which is heated over a fire, and stirred vigorously. Some of the grey precipitate from the filtered wood ashes is added, more oil is poured in, and the whole is stirred together. The oil turns frothy, and unless the mixture is kept well stirred it will boil over. More oil, strained wood ashes, and water are added from time to time until finally the mixture is boiled to remove the water; the size and strength of the fire is gradually reduced and the soap gradually becomes thicker and stiffer until it is allowed to cool and is rolled into balls, which are

then ready for use. The soap is generally of a dirty greyish-black colour, although in some districts it is yellowish. Such home-made soap is 'soft' in its action, that is, it produces a good lather in water. It is used for general washing purposes, but it has rather an unpleasant odour which tends to remain in clothes which have been washed with it. Probably further work on African soap-making from local products would result in some other substance being discovered which, if added, could either get rid of this unpleasant odour altogether, or even replace it with a more pleasant one, such as is added to certain imported soaps.

As we have seen, in preparing pericarp oil the fibres and nuts are first removed. The nuts are put out in the sun to dry for a few days, during which the kernels shrink slightly and are easier to remove whole when the nuts are cracked. The shells are of varying thickness. Obviously varieties with the thickest shells are hardest to break.

The kernels are usually broken by hand, either by cracking them with a pestle in a mortar, or with stones. (Plate XXI *b*.) They are very rich in oil. Most nuts contain only one kernel, but often two and occasionally three kernels are found.

In Nigeria particularly attempts have been made to introduce simple machines for cracking the nuts. Some are worked by hand, others by small engines, and some even by an arrangement by which the power is supplied by pedalling with bicycle pedals from an old cycle attached to the machine. These are known as 'treadle mills'. The nuts are revolved quickly and broken against a revolving wheel. The kernels are collected and the broken shells generally thrown away. These shells are very hard and are used in many parts of West Africa in blacksmith's fires where they serve as excellent and slow-burning fuel.

In old times in West Africa the value of kernel oil was not realized and most of the nuts were either thrown away or used whole as fuel in blacksmith's furnaces.

The main West African industry in palm kernels is from Nigeria and Sierra Leone. As the oil is difficult to prepare and does not keep well in transit, traders sometimes buy the uncracked nuts. These are cracked and the oil extracted from the kernels by machinery in Europe.

When West African palm kernels are removed from the shells and sold to traders there are three main defects in them. These are (1) insect-attacked kernels; (2) mouldy, soft, or

decomposed kernels; and (3) shell, fibre, or other impurities. Of these the last is most serious, as African farmers often fail to remove particles of the shell which adhere to the kernels. This is due to imperfect hand methods of breaking the nuts and is so common that traders assume that 5 per cent. of the weight of every bag is made up of shell.

In West Africa oil is usually extracted in two ways. The first is to roast the kernels in a pot, stirring them constantly. The oil gradually comes out, but is partly charred or burnt in the process and is dark brown in colour. After the oil has come out the kernels turn quite black. When no more oil comes out, and when the kernels seem to consist of pure charcoal when crushed with the foot or with a stone, then practically all the oil has been extracted and the kernels are thrown away or used as charcoal.

The second method is more laborious. The kernels are soaked in water and are then crushed to a fine state, in a tall, narrow kind of mortar, generally in the evening. They are then placed in a vessel, some warm water is added and it is then put in a cool place overnight. In the morning the oil has risen to the surface and is easily skimmed off with a spoon.

Some of the oil on the surface is mixed with tiny portions of broken kernel which rise with the oil. This substance, together with a certain amount of water, is skimmed off with the oil. This impure oil can be purified or clarified by heating over a fire, when the water vapour is gradually driven off, and the impurities fall to the bottom. The pure kernel oil can be poured off into a bottle in a hot liquid state. This clarified oil, if carefully heated, and if all vessels used in the process have been clean, is almost white or pale yellow and is free from the carbon and dark colour due to the charring which occurs in the other process of extraction.

Palm-kernel oil, after extraction, is used in West Africa chiefly as a pomade for the skin. Sometimes it is mixed with imported scents such as lavender and Florida waters and used by women as a hair oil.

The kernel oil is also used as cooking-fat in African cookery. A home-made furniture polish can be made by mixing palm-kernel oil and kerosene.

In Europe it is used for edible purposes, such as in the manufacture of margarine, for cooking-fats, and in making pomades, soap, glycerine, and oil paint.

The residue left after the oil has been removed is rich in carbohydrates and proteins. In Europe it is pressed into cakes and sold to farmers as palm-kernel cake. This is a useful food for milking-cattle, but is rather unattractive to them at first as it is rough to the tongue. Farmers generally add molasses to such cake, after it has been broken up, so as to help cattle to eat it. Once they have acquired the taste for this cake the molasses is gradually removed and cattle are able to eat it with good effects on the milk yield. It is more usual, however, to use palm-kernel cake combined with more palatable cakes in feeding cattle

CHAPTER XX

THE COCONUT (Cocos nucifera)

This plant is probably the most useful member of the plant kingdom. It is grown in all parts of the tropics, but it is most fully used in the East and in the South Seas, every portion of the plant being put to some useful purpose.

Although the coconut is generally seen at the sea-coast, it can be grown with as great success inland, provided that the soil is well drained. Coconuts do not like clay soils, and do best in loamy soil where there is good drainage and an underground flow of water. In rich soils of this nature the best results are obtained.

There is a small industry in coconuts (copra) at Badagry in Nigeria and in Quittah and the Western Province of the Gold Coast. The coconut is grown from seed, and great care should be taken in selecting seed for planting. All nuts should be shaken first, and if the liquid can be heard inside the nuts are likely to be fertile. Nuts which contain no 'milk' are likely to be infertile. If a nut is dense it sometimes means that the inside has decayed. While good-sized nuts should be chosen, nuts that are very big generally have a thick fibrous coat which is a disadvantage when one is selecting nuts where good kernels are required. Large, well-formed nuts are most likely to contain the largest kernels, and when planted will yield better fruits than nuts sown at random. Green and under-ripe nuts should not be chosen.

The nuts are picked up from the ground and not from the tree. They generally fall at night and should not be allowed to lie on the ground more than three or four weeks before planting.

Coconuts are planted in nursery beds in good rich sandy loam. (Plate XXII *a*.) They are planted in rows 3 feet apart. Trenches 1 foot wide and 6 inches deep are dug in straight lines and the nuts are planted on one of their three flat sides. There should be a space of about 2 inches between each nut planted, and all should be practically covered with soil.

After a few weeks the first seed leaves appear (Plate XXII *b*), and the roots force their way through the fibrous husks and into the soil. After four to eight months the germinated nuts are ready for transplanting into their permanent positions.

Large holes are prepared 25 to 30 feet apart, each hole being

preferably 4 feet in diameter and 2 feet deep. The subsoil is removed, and the surface soil is mixed with humus of some kind and put into the hole. When it has three or four leaves the young coconut is transplanted in wet weather, and it is planted so that the soil in the hole is 6 inches or 1 foot below the surface of the surrounding soil. In the early stages of a coconut plantation the main work is to keep the young plants free from weeds. This is best done either by inter-cropping, by green manuring, or by the planting of cover crops. Inter-cropping is a difficult matter, and new coconut plantations are generally made along the sea-coast where it is usually impossible to grow other crops economically. Inland, however, where other crops such as corn, cassava, or other food plants could be grown between the trees, this should be done as it helps to keep down the weeds.

Where possible the planting of leguminous plants is advisable, annual green manure crops such as sword beans, *Mucuna*, *Calopogonium*, *Dolichos*, and others being suitable to smother the weeds. (See Plate I *a*.) Perennial leguminous plants such as pigeon peas, *Tephrosia purpurea*, or others are also suggested as they do not require planting every year and are cheaper to maintain, since they form a thick shade and only require moderate weeding.

After four or five years the trees flower and produce their first fruits, but it is only when they are five to eight years old that they begin to bear proper crops.

The flowers of the coconut are produced on several stalks each covered with small male flowers, and with one, two, or three swellings at the base of each stalk. These swellings, which look like undeveloped fruits, are really unopened female flowers which later produce three tiny stigmas at their tips. Cross pollination is brought about by insects, the female flower remaining receptive for a short period of only a few hours. Although there are three stigmas and therefore three ovaries in the female flower, only one develops in the fruit. This can be proved by probing the three holes in the mature nut, when it is found that two of them are hard and the other is soft. It is in the soft one only that the embryo develops and grows. In other words the whole interior of the fruit is taken up by one developing seed only, and not by three. The white kernel inside the nut is rich in food, notably sugar, proteins, and oil, which are used for nourishing the developing seed after it is planted. In the centre of the nut is a sweet-tasting almost colourless liquid, 'coconut

milk', which is a refreshing drink. This milk is gradually absorbed in the germinating seed, as will be seen later.

The green fruits, before they are fully ripe, are sometimes cut down, split open at one end with a cutlass, and the sweet liquid inside is drunk. The thin soft kernel is scooped out and eaten and contains much less fibre than in the ripe fruit. Green coconuts are sometimes sold in markets for these purposes.

During the early years of a coconut palm's life it is subject to certain diseases and pests. One of the commonest of these is the rhinoceros beetle (see Fig. 33, p. 316), a large black beetle with a short horn, which bores its way into the tender growing-point of the palm. Its presence there can often be discovered by small wads of fibre which the beetle thrusts out from the entrance to its hole as it bores its way deeper into the growing-point. If these beetles are allowed to injure the tree in this way without being stopped, they eventually kill the terminal bud, which can then be pulled out with the fingers. At this stage the palm is doomed, for it has no power of producing side branches. The only way to get rid of this insect, therefore, is to push strong wires down the hole made by the beetle, and kill the insect by pushing the bent wire through its body, after which it can be removed easily by withdrawing the wire.

The rhinoceros beetle lays its eggs in heaps of decaying rubbish, compost heaps, and piles of farmyard manure. The larvae are large fat white 'grubs' which feed on the rich humus until they reach the pupal or resting stage, after which they emerge as fully grown beetles, and at once seek the nearest coconut trees.

Coconut palms are also often troubled with scale insects. At Badagry in Nigeria much damage was done by a sudden alarming increase in these scale insects which were fortunately checked by the appearance of a large lady-bird beetle which fed on the scale insects.

Scale insects live in thousands on the under-surface of the leaflets, and suck the juice from the leaves which turn yellow in patches. This spotty yellow colour of the leaflets is generally a sure indication that the tree is infected with scale insects. These insects belong to the group of 'sucking insects' and are best dealt with by spraying the under-surface of the leaves with kerosene emulsion. This covers up the breathing-tubes of the insects which die of suffocation (see chapter on 'Insect Pests').

Sometimes coconut trees, especially introduced varieties, suffer from a stem bleeding disease. This is caused by a fungus,

and generally occurs about 6 feet from the ground. A brown liquid oozes out from the trunk, forming a dark brown patch on the outside which finally turns black. If this patch is cut into with a knife, the tissue beneath is seen to be decaying and is dark in colour. If it is pressed a dark coloured liquid can sometimes be squeezed out, particularly in damp weather. Unless dealt with, this disease spreads up and down the trunk, generally on the same side of the tree. All diseased portions should be cut away with a knife as soon as they are noticed, and carefully burnt. The wound should then be burnt inside with a torch, and finally covered over with a thick layer of coal-tar which acts as an antiseptic and preservative. If the disease has reached an advanced stage, the only solution is to cut down the whole tree and burn it, but if the disease is dealt with promptly in the way described, its life can generally be saved. Numbers of Ceylon coconut trees on the Assuantsi Agricultural Station on the Gold Coast have been cured in this way, and are continuing to bear good crops.

One of the main commercial uses of the coconut is in the preparation of copra. Copra is the name given to the white kernel of the coconut which is always dried in some way before it is exported, as it would not keep in transit otherwise. For the making of copra ripe fruits are chosen. The best fruits are those which have fallen to the ground and which have not begun to germinate. If they contain liquid when shaken then they are obviously suitable. If copra is to be made on a large scale, however, more nuts will be required than those lying under the trees, so that the trees must be climbed and ripe nuts cut down. This is quite an expert piece of work, and climbers are able to tell at a glance, or by slightly shaking the fruits, when they are ready to be picked. The ripe fruits are then collected into piles, allowed to lie for as long as a month, and are then split open. (Plate XXIII *a*.) In West Africa an axe is generally used for the purpose, but in other parts of the tropics where larger quantities of copra are made, the nuts are split on a sharp iron spike driven into the ground with the point sticking upwards.

After splitting, the liquid inside is spilt and the kernels are either removed at once with sharp knives (see Plate XXIII *a*) or allowed to lie in the sun for two or three days when they become partly dried and the edges curl over. It is then easier to remove them from the shells. In a fresh nut there is 45 per

cent. of water, the greater part of which has to be driven off in the manufacture of copra.

The kernels may be dried in three ways: by sun-drying, by smoking, or by oven-drying. Sun-drying is the method generally adopted in West Africa, especially along the coast where, in many districts, the climate is not too damp. The kernels are split into two or more pieces and spread on a dry surface (Plate XXIII *b*) or even on flat concreted areas which are specially made for the purpose. Large tarpaulins are used for covering them at night or when rain falls. Insufficient care in the sun-drying of West African copra is responsible for the fact that it often becomes mouldy and of poorer quality than copra from the Pacific or the Eastern tropics. Great care should be taken of it during drying and storing, so that it may be kept dry and as free from moulds as possible.

The smoking of copra is another method adopted and is generally done by placing the kernels on grids over an open fire, either out of doors or in a covered but ventilated shed. This process quickly dries the kernels, which are discoloured by the smoke, although they appear to keep well. The keeping quality of smoked copra is accounted for by the creosote and other disinfecting substances present in the smoke. These, together with the carbon formed by smoking, are impurities in the final copra which is, as a consequence, of poorer quality than sun-dried copra and is used for making cheap soap and candles.

Oven-dried copra is made by drying the kernels in specially constructed ovens. (Plate XXIV *a*.) There are several kinds on the market and they are specially imported into West Africa and other parts of the world from Europe. They are all similar in method if different in detail and consist of a furnace at one end, iron pipes or flues circulating throughout the furnace and giving the heat required to dry the kernels which are put on iron trays with open wire bottoms. The smoke is led away through the flues to a chimney at the other end of the building, so that it does not come into contact with the copra. The copra is placed on the trays (Plate XXIV *b*) and put into the drier, the trays being arranged one above the other with the hot flues between them. The furnace is fed with the coconut husks, so that little need be spent on fuel. After twenty-four to forty-eight hours the kernels should be dry and are then removed. They are of a yellowish-brown colour, smaller in size than when they were put in, and much oilier, owing to

the water having been driven off. They have a strong and pleasant scent and are good to eat.

Oven-drying is quicker than sun-drying and appears to be better at first, but oven-dried copra often does not keep so well as thoroughly sun-dried copra. The reason probably is that in oven-drying the outer portion of the kernels is dried but moisture is not fully expelled from the inner portion. In good sun-drying, which is a much slower method, the kernel is dried more thoroughly all through and therefore keeps better.

One or two other minor *points in the preparation* of copra should be mentioned. First, some nuts when split open will be found to have begun germination. The embryo has begun its growth which takes place first inwards, a curious growth known scientifically as the haustorium, and in general language as the 'apple', gradually filling up the hollow centre of the nut. (See Fig. 21.) The apple is the absorbing organ of the young plant, and absorbs the sugary liquid or 'milk' first, gradually enlarging, and wherever it touches the 'meat' or kernel it changes it into a soft jelly-like substance which it gradually absorbs and uses for feeding the young plant. This 'apple' is soft and spongy and is a great delicacy to eat, as it is sweet and much softer and less fibrous than the kernel itself. Whenever the 'apple' is found in a coconut, however, it is of no value for the making of copra, and the kernel itself is of less value, and later on of no value, for copra making.

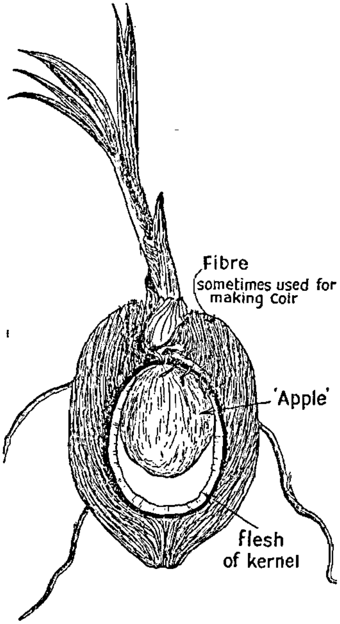

FIG. 21. Cross-section of germinating coconut showing 'apple', a special growth which absorbs the 'milk' and flesh of the kernel during germination.

Nuts which have been allowed to dry for some time before

splitting are better for making copra, and the flesh separates more easily from the shell.

Great care should be taken to store copra in a dry place as it is very hygroscopic, that is, it easily absorbs moisture from the air. In West Africa where the air is generally full of moisture owing to the high humidity, especially along the coast where the humidity is generally between 75° and 90°, dried copra very soon takes up moisture again, especially in the rainy season when humidity is at its highest. Therefore copra should be sold and shipped to Europe with as little delay as possible after its preparation.

The amount of moisture which copra takes from the air depends on the season. In the wet season it takes up more and in the dry season it parts with much of it. If the amount of water left in the freshly prepared copra is not more than 6 per cent., it can be kept safely for quite long periods. Green and grey moulds generally soon appear on the surface of such copra, but can be brushed off easily, showing that the flesh underneath is quite sound. The growth of such moulds is in fact an indication of the degree of dryness of the copra, as copra with more than 6 per cent. of moisture is soon attacked by black and brown moulds which cause decay of the flesh itself.

The grey and green moulds have very little effect on the copra and act only very slightly on the coconut oil contained in it. The black and brown moulds, however, cause the copra to rot and decay and the oil rapidly becomes rancid. Once the coconut oil has become rancid it is partly decomposed and free fatty acid is formed so that the copra is of much less value commercially for the manufacture of coconut oil.

The main points of importance in the preparation and storage of copra are (i) slow and thorough drying without being wet at all during the drying, (ii) storing in dry houses and shipping with as little delay as possible, (iii) keeping the moisture content below 6 per cent.

Copra is imported into Europe chiefly for the manufacture of coconut oil. The copra is first sliced or grated by machinery. The grated copra is then pressed and the oil comes out. This first oil is of the best quality and is used as food, for instance in the manufacture of margarine or in cooking-fats. Heat is then applied to the grated copra and further pressure is made which removes the major portion of the oil present. The oil which has been extracted with the help of heat is of poorer quality and is

used chiefly in the manufacture of candles. In Europe the best mills obtain over 70 per cent. of oil from the copra, which is a much higher percentage than is possible by hand power.

Nevertheless, coconut oil can be made by simple means in any African compound. Ripe nuts are mostly used and are split open, the kernel removed, the brown coating scraped off, and the remainder grated. The oil is pressed out with the fingers after placing the grated pulp in muslin bags. The liquid is thick and white, like milk, and is rich in oil. If hot water is poured over the muslin bag containing the pulp, and more pressure is given with the fingers, most of the oil can be squeezed out. This is sometimes called 'coconut milk'—not to be confused with the almost colourless sweet liquid contained in the ripening nuts. If this thick coconut milk is allowed to stand for ten to twelve hours in a cool place, the 'cream' rises to the top and an almost colourless liquid, consisting chiefly of water, is left underneath. This 'cream' rapidly goes rancid, however, and should be strained through a fine cloth to remove impurities, and should then be heated to drive off the water present. The fat melts, and appears as a thick layer on top, the water evaporates, and any remaining impurities fall to the bottom where they are burned, and the remaining thick layer of coconut oil can be poured off and cooled.

Another method is to allow the grated kernel to ferment for twelve hours, after which the liquid is gently pressed out, set aside for ten to twelve hours until the oil rises, after which it is skimmed off and heated or 'clarified' as before.

Coconut oil is used for various purposes in West Africa, mainly as a cooking-fat in cooking starchy and other foods, and also in frying fish. It is also used, sometimes mixed with other oils and scents, in rubbing on the body, or as a hair oil. Coconut oil is also used in Europe in the manufacture of pomades, as it is excellent for preventing the spread of dandruff.

Coconut oil is used in Europe chiefly in the manufacture of cooking-oils, margarine, and candles. The pulp left after the oil has been pressed out is called 'coconut cake' and is rich in sugar and proteins and contains quite a large proportion of fibres and a certain amount of oil. Coconut cake is sold to European farmers who use it for feeding dairy cattle, as it helps to increase their yield of milk.

The fibrous residue remaining after the extraction of the oil by home-made methods in West Africa is also rich in sugar and

proteins and contains a higher proportion of fat than the coconut cake made in Europe, because the African method of extracting the oil is not so efficient as the European machine method. The residue could be used for feeding pigs, or other domestic animals, and would serve as a rich food.

Desiccated coconut is obtained by grating the flesh of a ripe coconut that has previously been dried in the sun like copra. The brown portion should be removed from the outside of the kernel before grating. Desiccated coconut can be made easily in any African home in this way, and after grating it should be thoroughly dried on a piece of clean paper. If kept stored in an air-tight tin it should remain fresh and should last for a considerable time.

This product is made on a large scale in Europe, where it is used in confectionery, in the making of coconut sweets and cakes. It could be made and used in West Africa in the home in the making of cakes and sweets and in schools in domestic science classes. The home-made desiccated coconut appears to be richer in oil than the kind bought in the stores and imported from Europe. The latter has probably had some of its oil removed.

Another useful product of the coconut palm is the brown fibre produced in the fruits around the nuts (see Fig. 21), and which is known all over the world as Coir. If a ripe fruit is split open and the fibrous outside portion is examined carefully, it will be seen to consist of strong fibres each surrounded by a certain amount of softer pulp. Before these fibres can be used, the soft pulp must be removed, and this is done by a process known as maceration. The fruits are split open and the fibrous husk removed, cut into several pieces and left soaking in water for several weeks. Stagnant water is the best for this purpose, as it contains more bacteria which help in decaying the pulp. If stagnant water is not available, salt water is next best, while river water takes slightly longer to cause the maceration. This maceration or 'retting', as it is sometimes called, continues until all the pulp is rotted. If, however, it is allowed to go on too long, the fibres themselves become partly rotted and weakened in consequence. After retting is finished, the fibre is removed, dried, and beaten thoroughly to remove the remaining pieces of pulp. The fibres are finally scraped and combed until the longest and strongest fibres remain. These are known as 'bristle' fibres, and are used in making brushes. The shorter fibres are used in

making the well-known 'coconut matting' and the strong door-mats used for cleaning the feet before entering houses. The smaller combings are counted as 'mattress fibre' and are useful for stuffing mattresses, owing to their strength and elasticity.

Although coir fibre is coarser, more brittle, and has not such a good colour as other commercial fibres such as Sisal or Mauritius hemp, it is more elastic and is more durable under water. Coir ropes are useful where there are sudden strains and are less likely to break as they are capable of stretching 25 per cent. of their length.

Coir ropes are more durable under water than most other fibres, and resist decay better. In some parts of the world the fibres are used in making fishing-nets. Coir is also occasionally used for caulking boats, that is as plugs in filling in cracks and holes, and as it swells under water, lasts for a long time and keeps the water out.

If perfectly ripe nuts are used, the fibres tend to be brittle, so that the best coir is made from fruits which are not quite ripe.

Coir husks are used in most parts of the tropics as fuel, such as in copra-drying ovens.

In certain parts of West Africa fresh coconut fruits are used in making a reddish dye which is used in dyeing fishermen's nets.

There are other minor products of the coconut. In parts of the Eastern tropics the flowering stalk is used in obtaining sugar, and also a sweet liquid known as Toddy, which resembles palm wine in many respects. The sugar which can be obtained from it is of about the same composition as cane sugar and known in the East as 'Jaggery'. The unopened flowering sheaths have their tips cut off, and bamboo or small earthenware pots are attached, while the flowering stalk is gradually bent over. Fresh cuts are made frequently to stimulate the flow of sap which is collected in the bamboo pot and removed at intervals. Clean pots are used continually and the sap is removed quickly and boiled.

Toddy is sometimes allowed to ferment to such an extent as to be useless as a drink. In this stage it changes into a useful form of vinegar.

As the microscopic plant known as yeast occurs in toddy, it is used throughout Asia as a source of yeast for making bread, just as palm wine is used for the same purpose in West Africa.

CHAPTER XXI

THE SHEA-BUTTER TREE (Butyrospermum Parkii)

The shea tree occurs wild in the Northern Territories of the Gold Coast, and in Northern Nigeria from the oil-palm belt in the south almost to the region of Kano in the north.

It is often confused with the iron-wood tree (*Lophira procera*), but the shea tree is easily distinguished by the longitudinal and vertical cracks in its thick bark. It sheds most of its leaves in the dry season and produces its white flowers sometimes before, or at the same time as its young leaves. The fruit which follows and reaches maturity during the month of May (Plate XXV *b*) falls to the ground when fully ripe. The fruits are green and the nuts are embedded in a fleshy layer or 'mesocarp' which is sweet and edible when ripe. Each fruit contains generally one or two nuts, or sometimes three or even four nuts. The kernel of the nut is rich in oil which is known in commerce as shea-butter.

The yield of shea trees varies greatly, one of the main causes of low yields being the bush fires which sweep through the grassy undergrowth when the tree is setting either its flowers or fruit. In those places where the shea tree is properly looked after, such as in rest house compounds, the yield is generally much higher. Even then, however, individual yields vary and crops are heavier one year than another.

The tree is generally useful, branches being used for firewood and the stems for house-building and other purposes.

At least two varieties are generally recognized, one having a roundish fruit and the other a longer and more pointed fruit.

As the fruits fall to the ground during the planting season, which is one of the farmer's busiest times, they are not always collected while in good condition. The farmers often bring home fruits the seeds of which have already started to germinate on the ground. These are mixed with fruits containing ungerminated seeds. During germination, certain changes take place in the seeds and their composition alters. Such germinated seeds are unsuitable for sale or for the preparation of shea-butter, and by using them, as farmers often do, they lower the quality of the kernels sold and of the butter finally prepared. Therefore only freshly fallen fruits with ungerminated seeds should be collected and used.

The fruits are taken to the village and often put roughly into heaps to allow the outside part to rot. Fermentation usually helps to kill the embryos of the seeds although sometimes the seeds actually germinate, which spoils the quality of the final product. Therefore embryos not killed during this fermentation should be killed by boiling. The nuts are broken with stones or by pounding in a mortar, and the kernels are removed with the fingers, or the broken pieces of brown husk are removed by winnowing in the wind. In sun-drying, the seeds should be dried as far as possible in the husks or 'shells' before breaking them. The shell can then be readily separated from the kernel, and the final drying of the kernel takes only a few days.

This may be done either in the sun or in special kilns. The sun-drying takes several days, and if done thoroughly the kernels keep better and there is less tendency for them to grow rancid than in the kiln-drying method. The latter method, although slightly different amongst the various tribes, is the same in principle in most districts. A cylindrical kiln is made of swish, generally 3 or 4 feet high and covered with a grass roof. Near the centre of the kiln a 'grid' consisting of intercrossed pieces of wood or iron is made, on which the kernels are placed. A slow fire is made, lasting five to ten days and nights, until the kernels are dried. In some districts the nuts themselves, and in others the kernels, are dried in this manner.

The dried kernels are generally sold by the farmer to other people who take them to larger centres, where they may be sold to European firms for export. At these centres they are often stored for a considerable time before being sold again to larger dealers. When carelessly stored much harm is done, as fermentation often takes place in the heap, which lowers the commercial value of the kernels. This is first caused by the kernels sold to these dealers being either germinated or not thoroughly dried. Such stores should be better ventilated and provided with special drying floors, and the kernels should be turned over continually so as to assist drying and prevent fermentation taking place. By careless storage the quality and amount of oil present in the kernels is seriously affected. The percentage of oil is reduced by the formation of chemical compounds called 'free fatty acids', and known to the traders as 'f.f.a.'. These are formed from the oil itself and reduce the value of the kernels themselves, and every attempt should be made to keep their percentage as low as possible. This can best be done by the

careful fermentation of fruits containing *ungerminated* seeds, the previous killing of their embryos by either fermentation or boiling, the careful drying of the kernels, and proper care during their storage.

The kernels are used in Europe for the extraction of a fat known as 'shea-butter' which is used for soap and candle-making and also in the manufacture of vegetable butter. The residue or 'cake' remaining after the extraction of the oil is of no value for feeding cattle but can be used as a fertilizer for applying to the soil.

The shea-butter industry appears to be entirely in the hands of women and children. Sun-dried kernels are usually used in the preparation of shea-butter, which is quite a specialized and involved process, certain villages in each district devoting themselves entirely to it. Considerable pride is shown by many of the villages in the quality of their shea-butter, which in some Yoruba villages is made in special distinguishing shapes.

Shea-butter is used extensively in West Africa, and has much the same uses in the grassy northern regions as palm oil has in closed forest country. It is used in cooking, in the preparation of ointments and pomades for rubbing on the body, and as an illuminant, in the same way as palm oil is still used in the south in those districts where kerosene oil has not yet taken its place.

Shea-butter is distributed widely and also finds a ready sale in many villages of the closed forest country to the south. Shea-butter prepared in the Northern Territories of the Gold Coast, for example, is sold in the villages in Apollonia, in the extreme south-west of the colony. Therefore, although shea-butter is not generally exported, there is a large internal trade in it.

Different tribes adopt different methods in the preparation of shea-butter. There are two main methods depending on whether the kernels are roasted or not. In Nigeria the Nupe and Yoruba people roast the kernels first, whereas the Hausas and Munshis do not roast them. On the Gold Coast the Dagombas of the Northern Territories first boil and dry the nuts, after which the shell is removed by light pounding in a mortar, the broken pieces of shell being removed later by hand winnowing.

The method of roasting the kernels somewhat resembles that already described in the extraction of kernel oil from palm kernels by roasting, except that it is on a much larger scale. Special swish-constructed ovens are used, varying greatly in size

and shape, but sufficiently large to hold several earthenware pots full of kernels. These pots, which are perforated with holes at the bottom, are filled with kernels and heated over the fires until the kernels shine with oil and begin to split. Properly sun-dried kernels only require heating for about an hour, but imperfectly dried kernels may require to be heated for two hours, or even more, during which time they should be stirred regularly to prevent them from charring.

The kernels are then removed while dark brown in colour and still hot, and are pounded in a mortar to as fine a state as possible. The result is a sticky liquid containing a number of unbroken fragments. Small portions of the pounded mass are next ground on large sloping pieces of stone with smaller stones held in the hands. All small pieces of unpounded kernel are crushed in this way and the resulting sticky paste is slid down into calabashes of water, where it remains overnight and hardens slightly, so that it can be crumbled between the fingers on the following day.

A process known as 'treading' then takes place, the paste being added to a large earthenware pot sunk level with the ground and containing about one pint of hot water. During the adding of the paste it is sprinkled with a little hot water and the mixture is allowed to stand for twenty minutes or so, after which the paste is trodden with the feet until it becomes too sticky to work. More hot water is added, and the treading continues until a grey-coloured spongy dough is left. This is then added, a little at a time, to large pots filled with cold water, and the dough is thoroughly worked with the fingers during the process. The fat rises to the surface of the water as a dirty grey-coloured scum (Plate XXV*a*), which is removed with the hands and washed in another pot of water. The crude shea-butter is squeezed into balls, as much dirty water as possible being removed by pressure with the hands.

This crude butter, which is of a dirty grey colour, is next refined. The balls are put separately into pots of hot water, each lump being allowed to melt before the next one is added. The contents of the pot are kept boiling and thoroughly stirred for two hours or more, during the latter portion of which only the top part is stirred. This boiling is generally done in the afternoon and evening, the fire is damped at night, and the process continues the following day. The first thin layer of scum is removed, and the next layer, which is usually clear and

brown, is carefully removed into calabashes. A dirty dark-coloured liquid remains at the bottom of the pot, and is shaken up with more hot water, and a somewhat darker coloured fat rises to the surface. This is of inferior quality and is either used for burning, or added to the next lot of paste or dough remaining after the treading process. The final black sticky substance remaining at the bottom of the pot is used by the Yorubas for sealing cracks in the walls of their houses.

The best quality oil removed during the above refining process is stirred violently in calabashes with pieces of stick for an hour or more, after which it begins to thicken. The thicker portion is then spread out round the edge of the calabash, left for fifteen minutes, then stirred, and spread out again. This stirring and spreading should be carried out in a cool part of the compound in the early morning, as otherwise the fat takes longer to solidify.

The resulting fat, which is half solid, is the final shea-butter, and is then put into small earthenware cups of various shapes. Later it is removed from the moulds, wrapped in leaves, and sold in the markets.

The colour of the butter varies from cream to grey, or is sometimes dirty brown, which is said to be caused by over-roasting. Cream-coloured butter is preferred for edible purposes and greyish- or brownish-coloured butter is sold at a slightly lower price. The presence of even small amounts of impurities is sufficient to discolour the butter.

The above is the Yoruba method of preparation, the Nupe method resembling it closely, except that the pounded kernels are *kneaded* with the fingers, first in cold and then in hot water, immediately after pounding, instead of being trodden with the feet as in the Yoruba method. After stirring the paste with water in a mortar, the fat is skimmed off and then refined by further heating and skimming.

The Hausa method of extraction, which can be used as an example of the 'cold' method, is roughly as follows. The sun-dried kernels are carefully pounded and screened and dried in the sun for one day. They are then put into twice their weight of water, allowed to soak overnight, and ground to a smooth paste on a sloping piece of stone. The paste is put into large calabashes and water is added in small quantities and the whole mass is then stirred. This operation is often carried out on river-banks. When the mass has begun to change colour an excess of water is added and the mixture is stirred vigorously.

The fat floats to the surface in a curd-like state, which is quite different from the sticky fat produced by the 'hot' method. After washing, the fat is squeezed into lumps and then refined in much the same way as the Yoruba and Nupe methods. The shea-butter prepared by the Hausas is usually of a good pale-yellow colour and is generally sold in calabashes.

The colour of the various butters depends upon the temperature to which the kernels have been heated, those prepared by the 'hot' method (Yoruba butters) being brownish in colour, or amber, such as Nupe butters, and those prepared by the 'cold' method (Hausa butters) being yellow.

In the Northern Territories of the Gold Coast the Dagomba people adopt a modified method of roasting the kernels for obtaining the oil, and the resulting shea-butter is of a brown colour.

On the whole the percentage of fat obtained from the kernels by the various African methods is low, and higher percentages could be obtained by more scientific methods of extraction, by using benzene for example.

The shea tree is of very slow growth and as it has only come to notice of recent years there has not yet been time for plantations to attain an age when they are in proper bearing. It is, moreover, a difficult tree to propagate, as the seeds germinate slowly, and even after two or three years the stems are sometimes only 3 or 4 inches in height. If they are then transplanted from the nursery to the field, they generally die, the main reason being that the tap-root of the seedling is often several times longer than the aerial stem. This characteristic is typical of many trees growing in the dry northern grassy regions and is a modification adopted by such trees to keep themselves alive by sending their roots down deep in search of water. It is therefore best to plant shea seeds 'at stake', that is, in their permanent positions. Although their growth is very slow to begin with, they grow much more quickly when their deep tap-roots are established and they have sufficient reserve food stored in them to push their stems and leaves up above the level of destructive bush fires.

Finally, as so few accurate records of the yields of kernels per tree and per acre exist as yet, and as the demand for shea-butter in the world's markets is limited and the prices not encouraging, it is still doubtful whether it will prove to be a profitable *plantation* crop for export purposes.

CHAPTER XXII

CITRUS FRUITS

MOST of the fruits of the citrus family occur wild in south and south-eastern Asia, where they have been cultivated for centuries. There are many different kinds, amongst which the sweet and sour orange, the lime, the lemon, the grape-fruit, the citron, and the tangerine are best known. There are numerous other kinds, mostly cross-breeds between these and other citrus fruits.

These are evergreen and are generally thorny shrubs or small trees growing up to 30 feet in height. The leaves have more or less winged leaf-stalks and are generally covered with dots which can be seen by holding them up to the light. These dots, when pressed, are found to contain delicate, strongly scented oils known as volatile oils. Similar dots containing oils occur on the rinds of the various citrus fruits.

In the Gold Coast citrus fruits grow best along the edge of the closed forest. This area extends from Axim in the west to Akwapim in the east, where it turns north, running through parts of Togoland and finally bending north-west through the *north of Ashanti.*

SWEET ORANGE [CITRUS AURANTIUM]

This tree is probably the most important tropical fruit in the world. In the past most oranges were grown in sub-tropical countries, such as those round the Mediterranean and in the Canary Islands. Nowadays more oranges are grown and exported from tropical countries, such as South America and the West Indies. Many parts of West Africa are well suited to the growing of oranges.

The sweet orange tree grows 20 feet high or more, is evergreen, and has an erect stem and a dense, well-proportioned crown. The leaf-stalks have small wings. The flowers are white, waxy, and sweet-scented. The fruits are round and begin to turn yellow when ripe. (Fig. 22 *a.*) In cooler districts they turn a golden yellow when ripe. The pulp is sweet, and the rind generally thin, although some oranges, like the Washington Navel, have thick rinds.

The orange tree has a deep tap-root and thrives in most soils if they are well drained. It does not thrive in very sandy soils.

In mountain districts of one or two thousand feet or more oranges seem to thrive, and on gentle slopes they seem to do well. Although strong sea-breezes do not suit them, they are able, because of their deep tap-roots, to endure strong winds and tornadoes when other trees are blown over.

Oranges are best propagated in the nursery, and can be grown from seed. As orange seeds quickly lose their vitality when dry, they should be planted soon after removal from the fruit. If they are to be kept for some time they should be put in damp soil or sand until needed. Orange seeds sometimes contain two or more embryos, which explains why two or more orange seedlings occasionally grow where only one seed was planted.

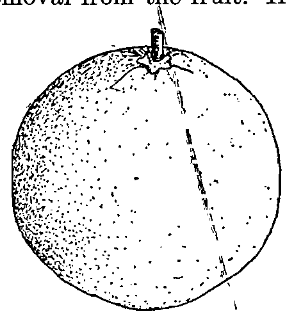

FIG. 22 (*a*). Sweet orange.

The seeds should be planted in nursery beds or seed-boxes, in good well-drained soil with 3 to 4 inches between each seed and 6 to 9 inches between the rows. Seedling trees are generally ready for transplanting to permanent positions after one year's growth in the nursery.

In most countries where oranges are grown from seed it has been found that after a few years the trees die gradually from a disease which attacks them a few inches above the soil. (See Plate XXVI *a*.) Thousands of orange groves all over the world have been ruined and old groves in West Africa are suffering in the same way. It has been discovered that the only way of preventing it is to bud or graft the sweet orange on a sour orange stock. (See section on budding and grafting in chapter on 'Propagation of Plants'.) For this purpose seedlings of sour oranges should be raised in the nurseries and transplanted into new nursery-beds after six to twelve months, 2 to 3 feet apart in rows 4 feet apart. After four to six months they are ready to have buds of sweet orange budded on to them. The budding of oranges is simple (see Fig. 32, p. 300) and after a further six months' growth the budded stock is ready for planting out. Buds from the seedlings of the sweet orange can be taken after six to twelve months of growth, but this method has the disadvantage that the characters of the seedlings are not apparent so early. Whenever possible, therefore, bud-wood

should be taken from trees whose fruits have proved satisfactory both in quality and quantity. Grafting is sometimes done, but budding is easier. When transplanting the seedlings or the budded stock, great care should be taken not to injure the long taproot. Any such injuries should be trimmed with a sharp knife. The young plants should be put into long holes filled with rich soil, and manure added when possible. They should be 20–25 feet apart, depending on the fertility of the soil. They should be transplanted at the beginning of the rainy season and most of the plants should grow well.

After transplanting, the growth is generally rapid and care should be taken not to allow suckers to form. These should be removed close to the stem with a sharp knife, and the plant pruned to a single stem, branching at 4 or 5 feet from the ground. Orange trees should not be heavily pruned, but require constant trimming. All suckers near the base of the stem should be removed and dead and badly shaped branches cut off. As the fruit is produced on the young wood, the tree should be kept lightly pruned to a round dense crown.

The trees should be manured yearly if possible, by forking in animal or other manure. Care should be taken not to hoe too deeply, as the surface-roots are easily injured.

Vegetables and other quick-growing crops can be grown between the trees in their earlier stages, but as the branches meet, no intercropping should be done. The soil should then be lightly forked and not allowed to grow hard. On slopes where soil-wash occurs, the trees can be intercropped with some green manure or leguminous crop, such as *Calopogonium mucunoides*, which helps to hold the soil and at the same time adds manure in the form of masses of dead leaves. Later on, the green manure can be dug in to enrich the soil still further.

Oranges respond readily to irrigation. The most suitable form is channel irrigation, as practised at Achimota, Gold Coast, on the Irrigation Farm. Orange groves under irrigation thrive in dry districts where otherwise they could not possibly grow. Orange trees should never be grown under the shade of other trees as they do best in direct sunlight. When grown under irrigation they should be allowed to rest for a month or six weeks yearly, when no water should be given to them.

Generally after five years orange trees come into bearing, and after ten years they are at their best. Some trees bear better than others, and where a tree produces particularly heavy crops, the

fruits should be thinned out in their early stages, as the production of such heavy crops may weaken the vitality of the tree.

Orange trees can be grown from cuttings and by layering, but these methods are not so satisfactory as budding or grafting.

Orange trees are generally healthy, but are sometimes attacked by insect pests. Of these the citrus moth is by far the worst and is, in fact, the controlling factor in West Africa for all sweet-juiced citrus fruits, such as orange, grape-fruit, and tangerine. Another less important pest is the scale-insect which causes the leaves to turn yellow and fall, thereby weakening the tree. Scale-insects can be killed by two or more applications of kerosene emulsion. (See section on spraying in chapter on 'Insect Pests'.)

The green caterpillars of the swallow-tail butterfly (*Papilio demodocus*) sometimes cause great damage by eating the leaves. They can be killed by the application of a stomach poison in the form of arsenate of lead.

The worst complaint of orange trees and most other citrus fruits is known under the various names of gummosis, bleeding disease, collar disease, 'mal-di-gomma', 'die back', etc. This attacks the trees just above ground-level (see Plate XXVI *a*), causing gum to ooze out of the tree. The disease moves up as well as down, finally killing the roots and stem. (Plate XXVI *a*.) Putting coal-tar round the affected portion *may* prevent or retard its progress, but most affected trees die from the disease. The cause of the complaint is not fully understood. It starts as a dark colour and the wood underneath the dark portion is soft. It is believed that injuring the trunk with hoes or other tools when weeding or cultivating causes the trouble to spread in the first place. As the complaint generally attacks seedling trees, the best prevention is to grow sweet orange on sour orange stocks.

If the disease is discovered early, it is sometimes possible to save the trees by planting seedlings of sour orange round the base of the trunk (Plate XXVI *a*), and 'inarching' them, that is cutting off their tops later and grafting the tops into slits in the bark of the tree above the diseased crown.

THE LIME [CITRUS MEDICA var. ACIDA]

After the orange, the lime is the most important citrus fruit. It is chiefly used commercially for the manufacture of lime-juice and citric acid. Nowadays, however, lemon squash, grape-

fruit juice, and orangeade are increasing competitors with lime-juice. Also larger quantities of artificial or synthetic lime-juice are being manufactured.

The lime is a small bushy tree, branching nearer the ground than the orange tree, and spreading much more. Its tap-root is not so deep, and its surface roots are more spreading.

The twigs are thorny and the leaves have winged leaf-stalks. The flowers are white, waxy, and sweet scented, and the fruits are small, pale yellow, with a slight swelling at the tip. (Fig. 22 *b*.)

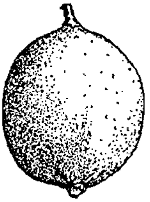

FIG 22 (*b*). Lime.

Lime trees require much the same kind of climate as orange trees and therefore thrive in most parts of the forest country in West Africa. As the roots are not so deep as those of the orange, the lime should not be planted in situations exposed to high winds.

The lime is propagated by seeds, many of which are produced in each fruit. Some farmers prefer to plant the seeds 'at stake', that is, in their permanent positions, afterwards thinning out the plants that are not needed.

The usual system is to plant the seeds in nursery beds 3 or 4 inches apart with 6 or 8 inches between the rows. After six months the seedlings can be transplanted to their permanent positions in specially prepared holes which vary from 15 to 20 feet apart both ways, depending on the quality of the soil. In poorer soil they are planted close together, and in good soil farther apart.

Their growth is rapid and little pruning is necessary, beyond the removal of suckers and dead or weak branches. After three or four years the tree comes into bearing and remains in fruit most of the year round. As a rule the fruits should not be picked from the tree, but should be allowed to fall naturally and then should be picked from the ground without delay, at which stage they are said to contain more juice. On no account should trees be shaken, as young fruit and flowers are destroyed in this way. Where fresh fruits are required for export, the fruit should be picked fresh from the tree as fallen fruits tend to be bruised.

Limes respond to manure, especially farmyard manure, where this is obtainable and is added in moderate quantities. Otherwise wood ashes and kitchen refuse could be dug in. Green manure crops can be planted between the trees and add food

to the soil, as well as preventing soil-wash on sloping hill-sides. (See chapter on 'Leguminous Green Manures and Cover Crops'.)

In the West Indies the fruits are crushed and the juice is refined and exported in casks.

The fruits are chiefly used in West Africa for making fresh lime-juice, a cooling and useful drink.

In West Africa the lime fruit is often used to rub on the skin after washing, or to cure skin complaints, although the lemon is more effective in this latter respect.

There is a small but healthy lime-juice industry on the Gold Coast where the lime-juice is extracted in a local factory. The fruits are crushed whole between rollers and the juice does not ferment like ordinary lime-juice, but is prevented from doing so by the juice from the rind, which acts as a kind of preservative. The juice is packed in drums and exported. Recently there has been an increase in the demand for the volatile oil which is distilled from the rind. This oil is used in the perfume trade and in scented soaps, and the demand for it seems to be increasing on the Gold Coast.

GRAPE-FRUIT [CITRUS DECUMANA]

The grape-fruit, so called because its fruits are produced in clusters like grapes (See Plate XXVI *b*), is a small tree like the orange in general appearance. Its climate and soil requirements are much the same as those of the orange and lime.

The leaves have winged petioles, which are shaped like an inverted triangle, white sweet-scented flowers and large round fruits, which are pale yellow when ripe. (Fig. 22 *c*.)

Two or more varieties are found in West Africa. One is large and coarse, shaped like a pear, and is known as the shaddock. The best grape-fruits are round and smooth-skinned, with a thin rind and few seeds. They are a popular fruit in America and are becoming more popular in Europe. In West Africa they are becoming more widely known every year.

They are generally propagated by seeds in nurseries at the same distance apart as limes and oranges and are generally transplanted between six and twelve months afterwards into holes 12 to 20 feet apart, depending on the nature of the soil.

Grape-fruits suffer from 'die back' in the same way as sweet oranges, and it is therefore best to bud them on sour orange stocks. (Plate XXVI *b*.)

Much effort is being made to promote an export trade in

grape-fruit from West Africa. Although the quality of the fruit is variable, much excellent grape-fruit is grown along the coast and several successful shipments of it have been made to Europe, and there seems little reason why the industry should not develop. One of the main problems is the amount of damage caused to ripening grape-fruit by the citrus moths. This damage can be partly prevented by picking the fruits a few days before they are fully ripe and completing their ripening in a store-house.

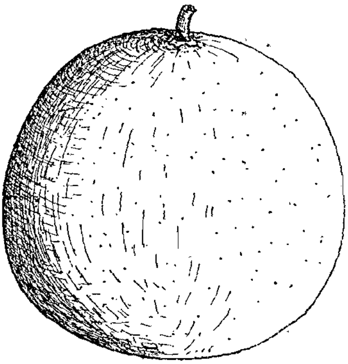

FIG. 22 (c). Grape fruit.

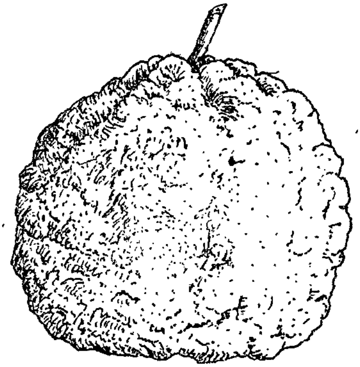

FIG. 22 (*d*). Rough-skinned lemon.

THE LEMON [CITRUS MEDICA var. LIMONUM]

The lemon tree resembles the orange and grape-fruit trees in many respects and requires much the same climatic, soil, and cultural conditions.

The lemon is grown chiefly in Italy and Spain, and citric acid is obtained commercially from it.

The lemon is chiefly used in the manufacture of lemonade, which has now largely taken the place of lime-juice in European countries. Most 'lemonade' sold to-day is a gaseous drink with little or no lemon-juice in it. Citric acid, prepared from lime-juice, or in other ways, is largely used for this purpose.

The lemon can be grown from seed and is susceptible to gummosis and does best when budded on sour orange stock.

The fruit can be used in making drinks and is also used in West Africa for rubbing on the skin after washing. The lemon is considered as even more effective than the lime in preventing scurvy.

The rough-skinned lemon (Fig. 22 *d*), a type with a thick rough

rind, is, however, practically immune from gummosis and is suitable as a stock in the same way as the sour orange. In South Africa it is largely used for this purpose and could probably be used with success in West Africa also.

THE SOUR ORANGE [CITRUS AURANTIUM var. BIGARADIA]

The sour orange (Fig. 23 *a*), sometimes known as the bitter or Seville orange, is little grown in West Africa. As its names imply, it is largely grown near Seville in Spain and has a bitter or

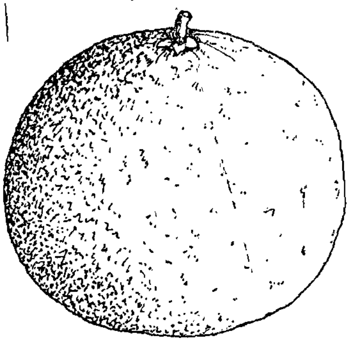

FIG. 23 (*a*). Sour orange.

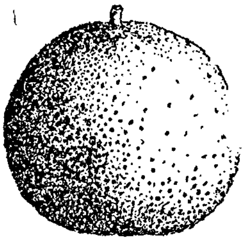

FIG. 23 (*b*). Tangerine.

sour taste. Most of the sour oranges grown in southern Spain are exported to England, where they are used in the food known as marmalade.

In general appearance and in methods of planting and growing the sour orange closely resembles the sweet orange, grapefruit, lime, and lemon. It produces plenty of juice which, although not so pleasant to the taste as that of the sweet orange, can be used in drinks. It could be more generally grown in West Africa for this purpose.

Sour orange trees are much hardier than other citrus fruits and generally resist the disease known as 'die back' or gummosis. For this reason the sour orange tree is generally used as the hardy stock on to which bud-wood of the other citrus fruits is grown. Therefore a supply of sour orange trees should be grown from seed in more parts of West Africa. Otherwise seeds or plants are obtainable from most of the Agricultural Stations.

Excellent home-made marmalade can be made from sour orange fruits.

THE TANGERINE [CITRUS SP.]

The tangerine is a small tree with smaller leaves and denser foliage than other citrus fruits. It bears small, round, orange-coloured fruits (Fig. 23 *b*) with a sweet golden pulp in the centre and an easily removed rind. Tangerines are susceptible to gummosis and trees do not seem to last long unless budded on sour orange stock.

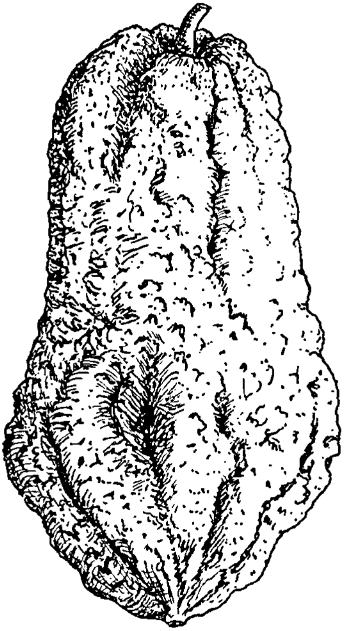

FIG. 23 (*c*). *Citron.*

THE CITRON [CITRUS MEDICA]

The citron is a large curiously shaped and coarse fruit with a rough skin. (Fig. 23 *c*.) The skin or rind is thick and the white pulpy layer is also thick, so that the amount of 'flesh' in the centre is only small and of no value for eating. The main use of citron fruits is in the manufacture of their thick rinds into candied citron peel, which is made by soaking cut pieces of rind in sugar syrup, and which can readily be made in the home. There is little chance of it ever developing into an industry in West Africa.

CHAPTER XXIII

BANANA. PLANTAIN

THE BANANA [Musa sapientum]

The origin of the banana plant is not known with certainty, as it has been cultivated in the tropics of the Old and New Worlds for such a long period of time. Although most people would deny that bananas produce seeds, this is not so, as various kinds of seeding bananas are known in different parts of the world. One kind from the Congo (*Musa Arnoldiana*) has been grown on the Gold Coast, and in Sierra Leone there is a wild variety which produces seeds and is called 'A polo' in Temne. The fruits of these seeding bananas are only 2 or 3 inches long, and are packed closely together. They contain practically no pulp, and several round black seeds about the size of a pea, which are used by Temne women as beads. These seeds when planted will yield new banana plants. In ordinary bananas the tiny seeds can be seen embedded in the soft pulp, but they are sterile and will not germinate. Cultivated bananas have therefore been developed, by artificial selection, from wild seed-bearing types.

There are many varieties of edible banana known in the Eastern tropics and in the West Indies, the banana being the main export crop in Jamaica. Some have been introduced to West Africa, and in Sierra Leone, for example, several of them have become thoroughly established. The commonest varieties are Gros Michel or Martinique, Red or Cuban banana, Man o' War, 'Apple' banana, Silver, Lady's Finger, Guinea Negro, and Chinese or Canary banana. All these varieties, with the exception of the Canary banana, grow tall. The Canary banana grows only 5 to 8 feet high, produces smaller fruits, and is, in fact, a different species (*Musa Cavendishii*). (Plate XXVII *b*.)

The Gros Michel banana grows to a height of 20 or 25 feet. It is a vigorous grower and produces large and abundant fruits. It is the main variety grown in the Jamaica banana trade. The Red or Cuban banana produces shorter and thicker fruits with a red skin. This variety has a somewhat peculiar flavour and scent, but the flesh is sweet; it is not liked by every one. The other varieties generally have smaller or less abundant fruit than the Gros Michel, and one variety, the 'Apple' banana, has a slightly acid taste like that of apples.

These introduced commercial varieties are generally taller

and have thicker stems than the common African varieties found everywhere. Although most of these introduced varieties have smaller fruits than the African varieties, their flavour and quality is much better.

The Canary or Chinese banana has been introduced and grown successfully in many districts, and is a sturdy plant and a heavy yielder. The fruits are small, sweet, and of excellent quality. (Plate XXVII *b*.)

The cultivation of the banana is simple, as it thrives in most parts of the coastal belt of West Africa. Although it will produce fruits, even in comparatively dry districts, it does best in closed forest country where the rainfall is anything from 40 to 100 inches or even more. Provided that the rainfall is sufficient, the banana can be grown even near the sea, the salt-laden atmosphere having no harmful effect. The banana can also be grown at altitudes of 2,000 to 4,000 feet, although at the higher altitudes the dwarf or Canary banana does better.

Bananas should be protected from strong winds and tornadoes which often blow down numbers of plants, especially those laden with fruits, the tall varieties suffering more in this way than the dwarf type. Even when exposed to moderate winds the leaves are torn into shreds, so that bananas should be planted in sheltered valleys or districts as far as possible, or otherwise special wind-belts of trees should be planted.

Provided the rainfall is sufficient, the banana thrives in most types of soils, except soils composed of almost pure sand or calcareous matter. The best yields, however, are obtained when bananas are grown in rich deep loamy or clay loam soils containing plenty of humus. Swampy soils should be drained by surface trenches before bananas are planted. In drier conditions or in sandy loam soil bananas can be grown successfully where irrigation, by means of surface channels of water, is practised, as in the Canary Islands. In many West African villages, bananas are planted near the bathing-places, or in those villages having a pipe-borne water-supply, they are frequently planted along the channels where the waste water runs away.

Before planting bananas the land should be thoroughly cleared, roots dug up and the soil thoroughly hoed, leaves and other humus being dug into the soil wherever possible. Holes are dug 12 feet by 12 feet which allows for 302 plants per acre. In Jamaica the plants are generally planted 14 feet apart, with two suckers in each hole, which gives 444 plants per acre.

Probably about 80 per cent. of these will bear, and of those about 75 or 80 per cent. produce bunches large enough to be fit to export. Some authorities recommend planting the suckers 15 feet apart in rows 18 feet apart.

The suckers required for planting should be removed with a cutlass or hoe from the base of heavy yielding plants. Narrow or 'sword' suckers should be avoided and only thick healthy suckers chosen, preferably those about 2 feet in length and several months old. Such suckers when in leaf are known as 'maiden suckers'. The leaves are often cut off before the sucker is planted. These suckers are sometimes left lying about for days before planting with very little harmful effect as they are rich in stored food, chiefly in the form of starch. Starch could, if necessary, be extracted from them, or they could even be eaten like a yam or a root of cassava. When the sucker sprouts in rainy weather, this starch changes to sugar and produces the leading shoot, smaller side shoots or young suckers being gradually produced.

Canary bananas, being much smaller, are planted closer together, at distances of 8 to 10 feet apart. The roots are numerous and fibrous, and feed fairly near the surface of the soil.

The land in between the young plants should be kept thoroughly weeded, and quick-growing vegetable crops or leguminous cover crops are planted to make use of the cleared land, and to keep the soil covered.

Most bananas bear fruit about a year after planting. Some farmers cut off the flowering 'knob' on the end of the flowering stalk, believing that this helps the fruit to grow larger and better, but this is doubtful. When the bunch has been cut, the fruiting plant should be cut down, chopped into pieces with a cutlass, and the 'trash', as it is called, heaped round the remaining plants where it gradually decays and manures the soil. In general it is best to leave only two or at most three plants in each 'hill', the others being cut out and used as surface dressing. Too many plants in a hill use so much plant food that the resulting bunches are much smaller. The first bunch is generally inferior to the second bunch, and after that the quality tends to become poorer.

The banana is an exhausting crop and most farmers allow banana farms to revert to bush after two years or more. A continuous banana plantation can be maintained if green manuring is practised, and if the hills are manured with farmyard manure,

wood ashes, or artificial manures. As such manures are not always available farmers sometimes move the position of the banana plants by digging new holes half-way between the old ones and planting new suckers there. This new plantation is made on the same piece of ground, and the soil round the original hills is rested after all the plants in them have been cut down.

When continual cropping is practised from the same hills, the size and quality of the fruit becomes poorer and it is then sometimes advisable to cut down and dig out all plants, add fresh soil to the holes, and plant fresh suckers from new and better plants.

Considerable attention has been given recently to the question of a banana industry for British West Africa, partly because of the decreasing prosperity of the cacao, cotton, and palm-oil trades. The banana thrives in West Africa which has the advantage of being fairly close to Europe; Sierra Leone being the nearest tropical colony to England. Moreover, the banana is an increasingly popular fruit both in Europe and the United States. The main market for West African bananas would at first be Europe. Most of the bananas imported into England are of two kinds: the Canary banana, which comes from the Canary Islands, and the Gros Michel banana, which comes mainly from Jamaica, where it is grown chiefly by peasant farmers of African descent.

On the Continent of Europe the banana is used far less as food, and its use could be developed indefinitely. Authorities believe that the Canary banana would at first be better for the continental trade, and Gros Michel for the British trade, although both types would probably find a ready sale in Europe.

Unfortunately the Gros Michel is susceptible to a wilting disease known as Panama disease, which is gradually weakening the Jamaican trade, and occurs also in Sierra Leone in districts along the railway. It affects other varieties such as 'Silver' and 'Lady's Finger'. So far Panama disease has not reached the Gold Coast or Nigeria, and every effort is being made to keep it out, as there is at present no known cure for it, although in the West Indies attempts are being made to breed an immune type. Otherwise the Gros Michel can be grown successfully in the Gold Coast and Nigeria, and limited quantities of it occur on Agricultural Stations and elsewhere. It is thick-skinned and stands fairly rough handling and can therefore be exported without crating.

The Canary banana thrives in many districts of West Africa. It seems to be immune from Panama disease, but being thin-

skinned, it unfortunately requires crating before exporting. The cost of importing special crating wood, as is done in the Canary Islands, is considerable, although useful crates could be made from local soft woods. In French Guinea they are exported wrapped carefully in grass bundles.

Bananas should be cut a week or ten days before they are ripe and should be put on board a fruit-ship with as little delay as possible. They are bulky and require careful handling, as bruises inflicted on even green fruits show as black patches when the fruits ripen. These patches lower the attractiveness and therefore the price of the fruits, and such patches generally go bad in storage and affect the surrounding fruits as well.

Good communications and nearness to good ports are therefore absolutely necessary. Bananas should be grown as near the coast or railways and roads as possible. On the Gold Coast, the districts surrounding Takoradi harbour are eminently suitable. Farmers, however, would have to guarantee a regular supply before special banana-vessels with proper refrigerator plants would undertake regular shipments, such as are sent from the Cameroons and from Conakry (French Guinea).

The banana is often used in West Africa as an intercrop in the early stages in the establishment of permanent crops such as cacao, oil, or coconut palms.

The banana is a very valuable fruit and food plant, as it is rich in proteins as well as in carbohydrates (sugar and starch). Bananas are used largely in local consumption in West Africa and are generally eaten raw.

There are several other ways in which they can be used.

Ripe bananas are often sliced, fried, or baked, and served with sugar and lime-juice squeezed over as a flavouring. They are sometimes sliced and eaten in mixed fruit salad.

Bananas may be dried, ground into a fine banana meal, and used for making banana bread by the addition of a double quantity of ordinary flour.

Banana cream can be made by mashing ripe bananas, mixing with cream and sugar, and putting the whipped white of an egg and cherries or other fruit on top.

A local substitute for vinegar can be made by placing mashed ripe bananas in a jar for a few days and straining off the juice every day into another open jar which is kept covered with muslin. This juice ferments naturally and turns sour, and when strained it forms a useful type of vinegar.

In West Africa the inner portion of the banana 'stem' is sometimes beaten before it becomes too dry and a useful fibre is obtained from it. A coarser fibre can also be obtained by pounding the flowering-stalk. This fibre is used by old people as a 'towel'.

When cutting down banana bunches or leaves care should be taken to keep the sap off the clothing, as it causes a bad brownish stain that cannot be removed by ordinary washing.

The dried skins of bananas are sometimes burnt to ashes and used in the making of home-made soap.

THE PLANTAIN [MUSA SAPIENTUM var. PARADISIACA]

The plantain so closely resembles the banana in appearance and requirements that it will only be dealt with briefly here.

A plantain plant looks so much like a banana plant that it is not always easy to tell the difference. The plantain is generally taller, and bears fewer, larger, and looser fruits which are sometimes curved upwards like a horn. The portion of the flowering stalk below the fruits is generally long, and partly covered with dead sterile flowers. In some plantains the flower 'knob' falls off after the last plantains have been produced. The fruits are larger, coarser, and thicker-skinned than bananas, and are richer in starch.

The plantain thrives in much the same climatic and soil conditions as the banana and is propagated in the same way, that is by suckers, which are planted 12 or 15 feet apart. Some authorities say that the plantain requires a richer soil than the banana. One acre of plantain is said to yield about 400 bunches of fruit.

Although in the Eastern tropics the word 'plantain' is sometimes applied to the larger types of banana, this is not so in West Africa where bananas are eaten raw, whereas plantains are either cooked first, or used as a vegetable.

Amongst certain tribes and in some districts in West Africa the plantain is the staple starchy food crop.

There are several varieties of plantains varying in size, shape, and number of fruits to the bunch. In Sierra Leone, the 'Maiden Plantain' has its fruits packed closely together like those of the banana, but the fruits are practically straight and have a long tapering neck. The 'Horse Plantain', so called because of the size and coarseness of the fruits, has each fruit separated by some distance from the others, and the fruits hang rather horizontally.

Plantains take twelve or fifteen months to bear after the planting of the original suckers, and continue to bear for four or five years, after which the quality of the fruits is poor.

Some varieties tend to split as they become ripe. This can be prevented by placing such fruits in water.

The plantain is generally used in the unripe state, when it consists almost entirely of starch and is usually roasted in oil, or boiled, and then eaten, either in pieces, or pounded into plantain 'fufu'. Sometimes the unripe fruits are sliced and put out into the sun to dry in much the same way as cassava 'kokonte'. If an ordinary knife is used in peeling or slicing fresh plantains the product is blackened, so that it is best to use a wooden knife. The fruit should be sliced in half and thoroughly dried in the sun. Unless the slices are properly dried, they soon become damaged by moulds or decay while in storage.

From dried slices of plantain a good flour can be prepared, by grinding or pounding them into a powder. If the pieces are only roughly ground it is called plantain meal, but if they are ground into a fine state by sifting out and regrinding all large particles, a finely divided plantain flour can be obtained. Plantain meal and plantain flour both keep for a considerable length of time. The flour can be mixed with twice its amount of ordinary white flour and made into a kind of bread. Plantain flour possesses the advantage over other starchy food that it contains proteins as well. It forms a good food for invalids and children.

Plantains are not exported from West Africa but are used locally as food. Before the War, however, the Germans were developing a trade in dried plantains from Cameroons. There is a considerable local trade in plantains in various parts of West Africa. In some parts plantains are regarded as an essential item of food, whereas the banana is a luxury.

The plantain also has other minor uses. The dried skins of the plantain fruits, when burnt to ashes, are used in the making of home-made soap, as they are rich in potash. The burnt dried husks are also mixed with ground tobacco in the making of home-made snuff on the Gold Coast.

Old people sometimes obtain a coarse fibre from the flowering stalks of plantains which they use as a sponge.

A fibre can also be obtained from the 'stem' of the plantain, this fibre being generally stronger and whiter than a similar fibre obtained from the banana 'stem'.

CHAPTER XXIV

MISCELLANEOUS FRUITS: MANGO, PAPAW, AVOCADO PEAR, PINEAPPLE, GUAVA

THE MANGO [MANGIFERA INDICA]

THE mango tree was introduced from tropical Asia to West Africa where it is so thoroughly naturalized that it is almost wild in places.

It is a quick-growing, spreading tree with a large and dense crown, and it remains in leaf throughout the year. The mango tree, like the silk cotton tree, has the curious habit of producing new leaves on one branch or at one side of the tree at a time, the leaves being reddish when young. The flowers are produced in clusters at the ends of the twigs and are small, greenish white, and scented. The fruits are roundish or oval and contain one large seed surrounded by fibres and embedded in a reddish-yellow sweet pulp which is edible. In the common mangoes grown in West Africa, the pulp of the fruit has a strong scent and flavour, like turpentine. The mango seed is an example of a seed with more than one embryo.

The mango thrives best in the hot coastal plains, and the best crops are produced by trees growing in deep, rich, well-drained soil in the valleys near the sea. They do not thrive at altitudes over 3,000 feet, and although mangoes are often grown inland in the closed forest country, they do not produce such heavy yields and the fruits do not mature so well, the leaves and fruits being often covered with crustose lichens. In the drier districts to the north of the closed forest the mango thrives, given rich soil and fair and reliable rainfall.

In West Africa the mango is generally planted from seed, and the seeds should be planted as soon as possible after removal from the fruits, as they lose their vitality very quickly. Mangoes are best planted at stake, as seedling mangoes nearly always die after transplanting. To avoid this, they are sometimes planted in bamboo pots or special baskets and then removed to their final positions. Should it be necessary to plant mangoes first in a nursery before moving them to their permanent position, it is best to transplant them as soon as possible after germination and in damp weather, for the older the seedling, the greater the risk of losing it after transplanting. The trees should be planted 20 to 30 feet apart, 25 feet being usually allowed.

Mango trees normally begin to bear four or five years after planting, and generally produce two crops within the year. The fruits begin to turn yellow when ripe, and when large quantities are to be picked should be gathered before they are quite ripe. They can be stored on shelves in cool, well-ventilated sheds for a few days until needed, and will ripen during storage.

There is a considerable local trade in mangoes in various parts of West Africa, and once established, the tree needs little attention. Dead branches should be removed and light pruning practised in the early stages to produce a good shape.

Inter-cropping of young mangoes with various food crops is generally practised until the trees meet and their dense shade prevents the growing of crops.

Although the mango is a very popular fruit in West Africa and is in great demand in the markets, it is a poor fruit compared with the Indian or West Indian mango. The improved, or Indian, mango is generally much larger, less fibrous, sweeter, and tastes less like turpentine. In fact an 'improved' mango fruit is one of the most delicious fruits of the tropics, and once West Africans learn to appreciate it, they will quickly take the trouble to grow these better varieties. The Rupee (a large round mango, shaped like the Indian coin, the rupee), the Jaffna, a longer and narrower mango of Indian origin, the Alphonse, also long and oval in shape, and the Parrot mango (a much smaller mango with a distinct parrot-like 'beak') are four of the best-known Indian varieties, all of which have been introduced to West Africa. Other Indian varieties and improved mangoes from Trinidad and other West Indian islands have been imported and successfully grown in parts of West Africa. Seeds taken from fruit of these improved mangoes generally produce trees bearing fruit like those of the parent tree. As the mango seed loses its vitality so quickly, it is generally impossible to send seeds of improved varieties from any other parts of the tropics to West Africa. Therefore it is always necessary, in the first place, to introduce these new varieties *as plants*. When these improved varieties produce fruits, their seeds can be sown, and although they generally remain true, they cannot always be relied upon. Some varieties are more likely to remain true than others, but naturally each generation grown from seed is poorer than the improved stock from which it came, and gradually 'reverts' towards the original wild mango. Seedling trees take longer to come into bearing than budded or grafted trees.

Therefore these improved varieties should be propagated by *vegetative* means, rather than by seed. Methods of doing so are as follows:

Grafting by approach. This is probably the best method, and is a form of grafting. (Fig. 24.) The ordinary semi-wild mango is grown from seed in a bamboo pot and when the stem is as thick as a pencil, or slightly thicker, the plant in its pot is taken to the mango orchard and grafted by approach upon the stem of an improved mango tree growing there. If such improved mangoes are seedling trees, the best trees are naturally chosen for grafting. A rough platform or large post is driven into the ground beside the improved mango tree, the bamboo pot with the 'African' mango is fixed on top, and a shoot of the improved mango is selected, about the same thickness as the stem of the potted mango. The stems of both mangoes, being of the same thickness, are then placed side by side, marked with a sharp knife, and a cut 3 or 4 inches long is made along the side of each stem where it faces the other. These two cuts are made very carefully so that each is of the same length and size. The two cut portions are placed face to face and tied securely in that position with raphia, sisal fibre, or thin twine. After the fibre has been tied tightly along the whole length of the junction the grafted portion is sometimes sealed with some local gum. The gum from the rain tree does quite well, while imported 'grafting wax' generally used for such purposes in Europe, is unsuitable in Africa, and seems to burn the stems. If gum is unobtainable, soft clay specially puddled with water can be moulded round the joined stems. The object of the gum or clay being placed round the joined portion is to help to prevent spores of disease from entering the wounds before they have time to heal up (see Fig. 24) (inset).

A tin or bottle of water is left at the base of the tree, and the mango seedling in the pot is specially watered every few days. Grafting is best done in the main rainy season when the mango tree is in its best season of growth.

The object of making both cuts of the same size and length is so that the cambium layers of both trees will face each other and can then grow together easily. After a few weeks, if the grafting has been done carefully, the two stems grow together. The portions of stems not required are then cut away. The portion of the 'African' mango *above* the join is removed with a sharp knife, and the stem of the improved mango *below* the

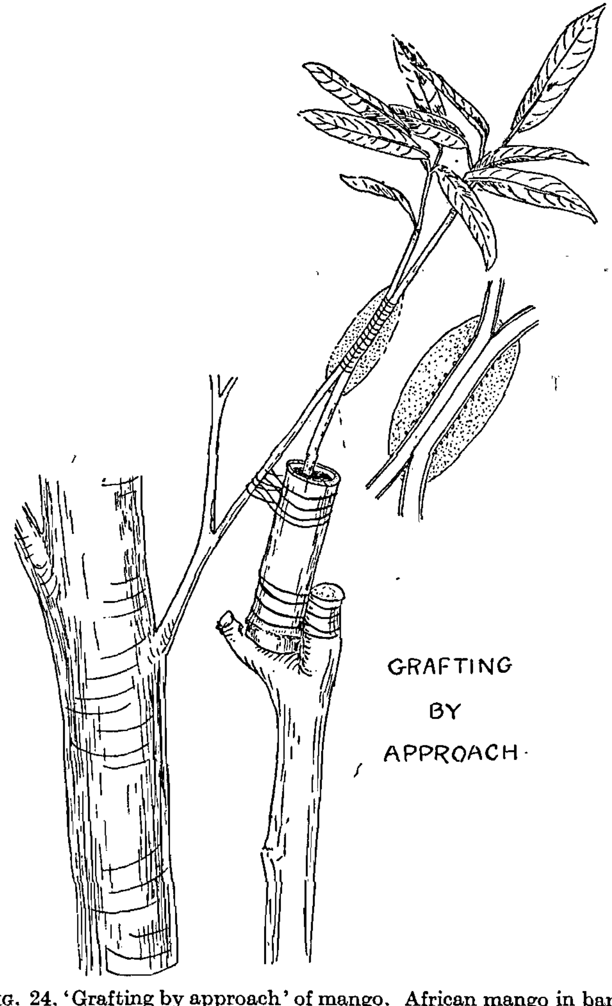

FIG. 24. 'Grafting by approach' of mango. African mango in bamboo pot being grafted to stem of improved mango. Inset: cross-section of graft.

join is also cut. The result is a young mango plant in the bamboo pot, consisting of the 'African' mango as 'stock', putting all its strength and hardiness into the improved mango or 'scion', which will produce the same fine fruits as the improved mango tree of which it once formed a part. The newly grafted tree can then be removed from the bamboo pot and planted in its permanent position. It should be tied to a stake to prevent breakage during storms. After three or four years practically all signs of the position of the grafting have disappeared and the tree is producing the same luscious fruits as the improved mango tree from which the scion came.

Budding of mangoes is sometimes practised, and fuller details of budding are to be found in the chapter on 'Propagation of Plants'.

Seedling mangoes of the common 'African' mango are grown in the nursery, buds being cut from the improved varieties of mangoes and budded on to the seedlings. Shield- or patch-budding is sometimes used, and in the West Indies experiments in the budding of mangoes has met with considerable success. In Jamaica it has been found that the larger the tree on which the bud was placed, the more rapidly did the bud grow. The authorities there recommend that the quickest way of establishing a new mango orchard of improved trees is to cut down trees of 6 or 8 inches diameter to 3 feet from the ground, transplant the stumps to their permanent positions, and as the new shoots appear, bud them with buds from trees of improved varieties. Not more than two or three shoots should be left.

Seedlings two or three years old can be used for budding, and stems at least 1 inch in diameter are said to be the best to which the buds can be grafted. After the buds begin to grow, the portion of the stem of the stock above the bud should be cut away.

Other methods of propagating mangoes, such as by layering and by the 'gootee' method, are given in more advanced books on tropical agriculture.

Besides being a valuable fruit tree, the mango tree has other less important uses. It makes an excellent avenue tree, having the advantage of remaining in leaf during the dry season. When mango trees are used in avenues care should be taken to see that the fruits are picked off systematically before they are ripe, and ripened in sheds and sold. Otherwise they drop to the ground and rot, or are stolen, and the half-eaten fruits left lying on the

ground afford food for swarms of flies which quickly become a nuisance.

The bark contains a tannin and can be used for tanning leather. The wood, though of value, being close-grained, tough, and not subject to cracking, is not generally used as timber in West Africa.

PAPAW [CARICA PAPAYA]

This plant is too well known to need a full description. It generally grows from 10 to 20 feet high and the main stem does not usually branch, but produces the leaves at the top. The remainder of the stem is covered with leaf-scars and is very soft in the centre, the older portions often being hollow. Near the top of the stem and beneath the leaves the flowers are produced on separate trees, the male flowers being on long stalks and numerous, while the female flowers are fewer and larger and are on short stalks. Papaw flowers have a sweet scent which attracts insects which pollinate the flowers. The male tree does not usually produce fruit. (Plate XXVIII *a*.) Some people believe that by cutting down the main stem of a male papaw tree, or by making a cut in the centre of the stem and inserting a stone or by injuring the tree in other ways it can be induced to produce fruit. It is likely that these injuries may stimulate the tiny undeveloped female portions which are present in male flowers, to grow to some extent. Occasionally a male tree is seen with clusters of small fruits chiefly at the ends of the lower flower sprays and also near the ends of the upper flower sprays. (Plate XXVIII *b*.) These are much smaller than normal fruits and are generally only 4 to 6 inches long, like mature fruits in shape and general appearance, and containing numerous seeds. These fruits often drop before they are fully ripe and the seeds are often immature and will not grow if planted. The fruits which are even sometimes produced by normal uninjured 'male' trees are probably similar in appearance to those produced by specially injured male trees. They are, however, much inferior to those of a normal female tree. (Plate XXVIII *c*.)

The papaw is generally propagated by seed and matures in between six and twelve months. Seeds can be grown at stake, or in the nursery first and when a few inches high transplanted, preferably in wet weather, to their permanent position.

Papaws can also be propagated by cuttings. These are

taken from trees with side branches. If these side branches are lopped off with a cutlass at the point where the branch joins the tree they can be planted out and will grow and mature quicker than if they were grown from seed. Branches of 2 to 4 feet long are preferred, larger branches bearing flowers or fruit being too old to transplant satisfactorily. These cuttings should be planted out in wet weather and should have their main leaves removed. They die back somewhat at first but quickly make new growth. It is advisable to plant several male plants amongst the female ones so that pollination may take place and proper fruit and seed be formed. An average of one male tree to twenty female trees is ample for this purpose. One advantage of this method of propagation is that the majority of cuttings may be selected from female trees, whereas the sex of seedlings will be uncertain.

The best fruits are produced by those trees which are prevented from forming lateral branches. These branches use up much of the sap which should go to the main stem. Though more fruit may be produced by a branching tree, it is smaller and of poorer quality. All side branches should therefore be pruned off and fewer and larger fruits will result. A papaw tree growing in good soil and well cared for may continue fruiting for two or three years or more.

There are two main West African varieties, those with long fruits and those with round fruits. (Plate XXVIII *c*.) The long-fruited variety is considered to be of better quality.

The papaw is a most useful fruit and should be used much more than it is. The white juice in the fruits contains a substance known as papain, which is used in medicine by European doctors for curing stomach complaints. Papaws are very easily digested and are an excellent food. Sometimes they are cooked when green, sliced, and eaten as a vegetable with meat. Generally they are eaten raw when ripe, or cut into slices with lime-juice added to improve the flavour. Ripe papaw makes a useful addition to fruit salad.

Ripe papaws mashed up or cooked are a useful food for young children, especially before they take meat or stronger foods, as it is easily digested and nourishing.

AVOCADO PEAR [PERSEA GRATISSIMA]

The Avocado pear tree, a native of Central America, was introduced into West Africa years ago and is now thoroughly

naturalized in many parts. It is still known as 'pear' in some vernaculars, proving that it was introduced by Europeans.

It thrives in the hilly moister districts of West Africa, and in closed forest country, especially at altitudes of 1,000 to 3,000 feet, and is sometimes called the 'mountain pear'. It also grows well in closed forest country at altitudes of less than 1,000 feet, but does not seem to thrive too near the sea, or in open grassy country.

In West Africa the Avocado pear is propagated by seed. It is generally planted first in nursery beds or pots and transplanted later. The seeds lose their vitality quite quickly, and should therefore be planted as soon as possible after their removal from the ripe fruit. They are enveloped in a thick seed-coat which is generally loose, and which should be removed before the seed is planted. The pointed end of the seed should be placed upwards, or, if the seed is round, the end which has been towards the stem in the fruit is placed upwards. About one-fifth of the seed is left above the surface of the soil and the seeds are kept well watered and shaded, and generally germinate within a month.

When six months to a year old the seedlings are transplanted to their permanent positions. The soil should be cleaned and dug beforehand and the plants planted 20 to 25 feet apart each way. The Avocado pear does best in a rich well-drained soil, soils that are too stiff or clayey being unsuitable. The trees should be protected from storms or tornadoes which break their branches by wind-belts of trees.

The usual rules are observed when pruning the Avocado, dead branches and thin spindly branches, or branches which fill up the centre too much being removed, and the tree pruned into a good shape, always remembering that the fruits are produced on the young wood.

After four or five years of growth, the tree usually comes into bearing. Trees grown from seeds are inclined to be very variable in their yielding capacities, and in the size and number of their fruits, some seedling trees not producing any fruits. Such trees are generally known as 'male' trees. It is because of the unreliability of seedling Avocado trees that vegetative methods of reproduction are adopted in the United States where Avocado pears are an increasingly important commercial crop.

The usual method adopted is shield-budding, the bud-wood being taken from heavy-bearing trees and budded on to strong

growing seedlings of the same type of pear. A very sharp knife must be used in budding, only clean cuts being made, and the buds inserted into T-shaped cuts on the stock plant. Occasionally grafting is also used in the United States.

The roots of the Avocado pear are surface feeders and for that reason the tree is best manured by leaf-mulching the surface soil, or by digging in green manure. The amount of moisture present at the fruiting season seems to affect the yield. Dry weather when the plants begin to flower seems to have little effect, but if it continues too long the flowers drop quickly and the crop may fail. If there is plenty of moisture available at the fruiting season the trees are more likely to bear well.

The fruits are usually used only for the local trade, and there is little chance of their becoming an export crop in the near future. First, their value as food is scarcely realized in Europe, where the demand is very small, and secondly they need very great care in transit, as they should be picked before they are ripe, and carefully packed. Even then they generally rot in transit.

Avocado pears are becoming increasingly popular in the local trade, but should be much more used, considering their high food value. According to Popenoe, their protein content averages about 2 per cent., and is higher than that of the well-known fresh fruits. Besides being rich in sugar, and in ash or mineral matter, which is also of importance, the Avocado pear is particularly rich in oil, and correspondingly poor in indigestible fibre. Thus it is an all-round food, and it is small wonder that it forms an almost complete midday meal for certain inhabitants of Central America. The percentage of oil present is said to vary from 9·8 to 29·1 per cent., with an average of 20·1 per cent., a very high percentage of oil for a fruit, the only other fruit resembling it in this way being the olive. The oil of the Avocado pear is also easily digestible, thus resembling butter-fat.

The Avocado is often cut up into pieces and used in vegetable or fruit salads, or cut in half and eaten raw, with pepper and salt and vinegar added as a flavouring. It is a highly valuable form of food, especially for children, and should be used far more. Its quality and yield should be improved by better methods of propagation.

The seed of the Avocado is large and is used in the West Indies in the preparation of a type of ink. If the seed is used for writing on a concrete wall, it leaves an indelible reddish-orange mark.

The fruits are generally either green or purple, but there seems to be very little difference in their quality.

It is said to be dangerous to eat the fruits when they are unripe.

THE PINEAPPLE [ANANAS SATIVUS]

The pineapple is believed to be a native of tropical America, but has been grown for so long in West Africa, where it was probably introduced by the Portuguese, that it is regarded almost as a native plant. In fact, in certain districts, especially when the vegetation is of the drier closed forest and thicket type, the pineapple has escaped from cultivation and grows wild in profusion.

There are several varieties of the pineapple, the Smooth Cayenne or 'Kew Pine' having no thorns along the edges of its leaves, so that it is an easier type to work amongst and to weed. Unfortunately, this type produces suckers much more slowly than the prickly-leaved varieties.

The majority of pineapple varieties are prickly-leaved, some of the best commercial varieties being Queen, Sugar Loaf, Ripley Queen (Mauritius), Red Spanish, Black Antigua, amongst others.

A type known as the Brazilian pineapple has been grown on West African Agricultural Stations and has a reddish and cone-shaped fruit. The Queen pineapple is one of the best known introduced varieties and produces large fruits of good quality. Various African varieties are recognized, the two main types being the red and the white (yellow) pineapple, according to the colour of the fruit. Of these two, the white or yellow type is most generally used.

Pineapples do best in a rich sandy loam, or loamy soil that is well-drained. They do not, as a rule, thrive on clay soils, but seem to require lime. They grow best at low altitudes and on low hills and do not seem to suffer from being grown near the sea, if soil and rainfall conditions are suitable. They like a fairly dry climate or one with a moderate rainfall.

Best results are obtained on newly cleared land, and plants with roots which might send up shoots again should be removed, as pineapples are a difficult crop to keep weeded. The plants should be grown in rows 3 feet apart, and 3 feet between every plant in the row. As it is difficult to weed amongst the prickly leaves, some farmers prefer to plant rows 6 feet apart, with plants

3 feet apart in the rows. This leaves a clear space between the rows which can easily be kept weeded. Other farmers prefer to plant two rows of pineapples 3 feet apart, and then leave a space of 6 feet before planting another two rows.

The pineapple is propagated by suckers which arise around the base of the parent plant. These suckers are hardy and can bear carriage for several days without harm.

During the period of growth the plants should be kept free from weeds, the soil kept thoroughly stirred, and in dry weather, dry cultivation or, better still, leaf mulching should be practised. After nine to eighteen months the fruits are mature and can be cut. When the fruits are to be exported they should be cut before they are fully ripe, and carefully handled to prevent bruising, as this causes them to rot in transit.

Some pineapple plants produce a number of suckers round the base of the plant. No more than two should be allowed to remain.

Suckers are also produced in the axils of the leaves, and a small bunch of leaves or 'crown' on the top of the fruit. These can be planted and will produce new pineapple plants, but are not such quick and effective methods of vegetative propagation.

Inside the fruit are tiny brown seeds. These are generally infertile, but some pineapples can be grown from seeds, new varieties being developed from plants grown in this way.

After three or four years the complete plantation should be dug up, as weeds are generally increasingly difficult to deal with, and the size and quality of the fruits have become poorer.

Pineapples are a flourishing local trade in places, and the internal trade in them could be developed considerably. Various trial shipments of pineapples have been made from the Gold Coast, but the fruit was invariably of poor appearance and quality or even rotten after arrival in England. Much greater care needs to be taken in deciding the proper stage of ripening, the most suitable varieties to grow, with methods of packing, the storage on the steamer, and the proper regulation of temperature on the voyage. A successful start with other export fruit crops is advisable before attempts are made to ship pineapples. Canning pineapples in factories set up in West Africa is a more hopeful proposition to begin with.

A strong and useful fibre can be obtained from the leaves of the pineapple. It is of a fine white colour, soft in texture, and of considerable strength. It is inadvisable to grow plants for fibre

and fruit at the same time. The leaves of the semi-wild pineapples are said to produce the better fibre and the cultivated varieties the better fruit.

THE GUAVA [PSIDIUM GUAJAVA]

The guava tree, originally a native of tropical America, has been introduced to all parts of the tropics, and is common in villages in many parts of West Africa.

It is a small tree, growing 20 feet or more in height, with a short trunk and spreading branches. The bark peels off in strips leaving the trunk and branches bare. The flowers are produced in the axils of the leaves on short stalks and have four green sepals, white petals, and numerous white stamens. The fruit is fleshy and contains many seeds.

There are several varieties known in the tropics, but in West Africa only two or three are usually grown. The best of these is the purple or Chinese guava (*Psidium Cattleyanum*) with large purple fruits of excellent quality. This guava, however, is not often found. A good variety is the yellow-skinned guava, which has a pinkish-red flesh and is full of numerous small seeds with a tart flavour. Another variety occurs as a weed in waste ground when once established in a district, and produces smaller fruits than the lemon-yellow ones. The fruits are reddish in colour and poorer in quality.

The guava grows easily in most soils and in both dry and wet regions. It does best, however, in rich, well-drained soils, with an average rainfall.

It grows readily from seed, which can be sown in nursery beds. The young plants can be transplanted when a foot or more in height. They die back somewhat after transplanting, but unless the weather is very dry they usually soon recover.

Guava trees generally come into bearing after two or three years. The purple variety and the yellow-skinned, red-fleshed variety are both excellent for eating raw, with or without the skin, the seeds generally being too hard to eat. The flesh has a pleasant and characteristic taste.

Probably the best use of the guava, however, is for making guava jelly. For this, fruits that are just ripe, but not over-ripe, are chosen. They are washed, cut into pieces, put into a pan, water is added in the proportion of half to three-quarters of a cup to 1 lb. of fruit, according to its juiciness, and they are cooked until they are soft and can be mashed into pulp. This

pulp is then put into muslin bags, tied with a string and hung up so that the juice may drain out, the seeds and pulp remaining in the bag being squeezed later to remove the last traces of juice. On the following morning 1 lb. of sugar is melted, a little water being added to prevent it burning, and a syrup is formed which is added to the strained guava juice. The mixture is boiled for twenty minutes, and is then poured into jars, where it sets into a firm jelly, red in colour. Guava jelly is of an excellent flavour, and is used largely in the West Indies, although as yet it is scarcely known in West Africa.

CHAPTER XXV

FLUTED PUMPKIN. WATER-MELON. PUMPKIN. SNAKE GOURD. CUCUMBER. CHOW-CHOW TOMATO. GARDEN EGG. PEPPER

For convenience, the list of vegetables included in this chapter can be grouped into two groups, according to the plant families to which they belong. These two families are the Gourd or Calabash family (*Cucurbitaceae*) which includes the first six, and the Solanum family (*Solanaceae*) which includes the last three, tomato, garden-egg, and pepper.

THE GOURD OR CALABASH FAMILY

[Cucurbitaceae]

This family of plants yields several well-known West African vegetables, besides the useful but inedible calabash. All these plants climb by tendrils. In most cases the male and female flowers are separate from each other, generally on the same plant, but sometimes with the male flowers on one plant and female flowers on another. They also have the peculiarity of bearing very variable fruits; the bottle gourd, for example, bears fruits of a number of different shapes. The fruits of other members of this family also vary greatly in size and shape and even in markings.

Most of them are strong-growing herbaceous annuals and thrive in a hot climate in rich well-drained loamy soils. They grow well under irrigation, provided that the soil is light and that they get plenty of water at their roots. They are usually grown on mounds of well-loosened soil to which compost or other well-rotted manure has been applied before planting takes place. The mounds should be 4 to 6 feet apart, according to the type of vegetable grown. The seeds are usually planted at stake. It is better to sow them in their permanent positions in this way, as they transplant badly. If too many seeds have been sown, the young plants can be thinned out later. Over-sowing makes allowances for the attacks of beetles or other insects which so often destroy the young plants. These beetles can be kept away by shaking arsenate of lead powder from a small sack on to the young plants in early morning when the dew is on them and the poisonous powder will stick to the leaves. The plants are sometimes trailed up poles, but this is usually

unnecessary, as they grow well on the ground provided that the fruits are kept off the soil as far as possible.

In West Africa there are a great number of plants of this family which are useful to man. Of these only the following will be dealt with in this book: fluted pumpkin (*Telfairea occidentalis*), water-melon (*Citrullus vulgaris*), pumpkin (*Cucurbita Pepo*), snake gourd (*Trichosanthes anguina*), cucumber (*Cucumis sativus*), and chayote or chow-chow (*Sechium edule*).

FLUTED PUMPKIN [TELFAIREA OCCIDENTALIS]

This is a large perennial and woody climber with five-lobed, deeply-divided leaves, male and female flowers produced in clusters on separate plants, petals delicately frilled at their tips, and creamy-white with reddish-purple centres. The fruits are sometimes over 2 feet in length, and nearly a foot in diameter and have ten deep ridges. (Plate XXIX *a*.) They are green and are covered with a white wax which wears off slightly as the fruit ripens. This wax can be rubbed off easily with the fingers. Inside the fruit is a bright yellow fibrous flesh in which there are 30 to 40 large red seeds over 1 inch in diameter, resembling cola nuts in general appearance. The cotyledons contain curious lumpy swellings, and the whole seed is rich in oil.

This plant is grown as a vegetable in certain parts of West Africa, notably by the Ibos, Ibibios, and Efiks, and also by some tribes of the Gold Coast. It grows best in the closed forest country and is especially grown on farms, where it is trained up large stakes or up neighbouring trees. It is sometimes grown on specially constructed arbours in African compounds. The Ibos often grow it on their cassava farms.

The leaves are edible. They are picked continually as the plant grows and are used in soup.

When the fruits are ripe they are split open, the yellow pulp is discarded, the large red seeds removed, pounded in a mortar and put into soup. Sometimes they are boiled whole, the seed-coat or testa is removed and the kernels eaten. The Efiks roast and eat the seeds which are nutritious and rich in oil. In the past these seeds have even been imported into England in small quantities as 'oil nuts'.

The plant is propagated by seeds.

WATER-MELON [CITRULLUS VULGARIS]

This is a creeping annual plant with hairy stems and deeply-lobed hairy leaves which are deeply divided and triangular in

outline. The flowers are small and yellow, and the fruits are large, circular in cross-section, up to 18 to 24 inches or more in length, and covered with light- and dark-green markings.

The water-melon occurs wild in places and is cultivated in most parts of West Africa and thrives in hot regions with a rich light soil. In desert parts of Africa where this melon thrives, it is one of the main sources of water not only to man but also to domestic animals and antelopes.

The light- and dark-green skinned variety described above has a bright reddish-pink flesh towards the centre, in which the flat black seeds are embedded.

This fruit is not usually eaten by West Africans as it is by American negroes, and the cool, slightly bitter, pinkish flesh seems to be eaten mainly by Europeans. There are several varieties of water-melon, some with stripes, others green or yellowish, and the seeds vary in colour from pale to black.

Another variety[1] has elliptical fruits, about a foot long and 6 inches across, with a pale-yellow skin. The flesh inside is white and contains numerous flat white seeds. The flesh is not eaten, but the seeds are used as food in many parts of West Africa. Sometimes they are dried in the sun, ground to a powder, mixed with spinach and put into soups.

The seeds, which are known in Nigeria and elsewhere as 'egusi', are rich in oil and can be eaten raw, but they are generally cooked in salt first. They are sometimes cooked and pounded, the husks removed and the kernels left for two or three days, after which they ferment slightly and are then used in soup. In some districts the seeds are roasted, husked, and made into balls which are eaten in soup.

The oil in the seeds has been suggested for use in commerce as a lubricating oil and for soap-making. The seeds contain about 25 per cent. of oil.

There are intermediate varieties between the green-spotted and the yellow-skinned varieties. The latter is grown more generally in closed forest country.

PUMPKIN [Cucurbita Pepo]

This is an annual creeping herb with more or less angular stems and lobed leaves. The petioles and the veins beneath are hairy. The flowers are large and bright yellow (Plate XXIX *b*): the male and female flowers are on different parts of the same

[1] Probably including *Cucumeropsis* and even other genera.

plant. The fruits are longer than they are broad, and circular in cross-section. They may be ribbed, smooth, or warty; creamy-white in colour, and with either green or green and white markings. The flesh is golden-yellow when ripe and the seeds are flat, with slightly raised edges.

The pumpkin is grown in most hot countries, and thrives in West Africa where there are at least two distinct varieties. It is often grown in compounds where it is sometimes trained up fences or even over roofs.

The flesh is generally boiled and eaten in pieces. The leaves are sometimes eaten as spinach, and in some districts the seeds also are eaten. Pumpkins are said to be an excellent food for pigs and cattle as well.

SNAKE GOURD [TRICHOSANTHES ANGUINA]

This is an introduced herbaceous climber, native of the Eastern tropics and grown in parts of West Africa. The leaves are deeply-lobed and dark green. The flowers are white with delicately frilled petals, and the fruits are long and narrow and cylindrical, green or greenish-white, and 3 to 4 feet or more in length. The snake-like appearance of the fruit accounts for its name 'snake gourd'.

The plant grows quickly and bears fruit three or four months after planting. The stems are generally trailed over a trellis-work so that the long fruits can hang down. They are sometimes kept straighter by hanging stones on their lower ends. In the younger state they are pale green with dark-green longitudinal stripes. They are generally sliced and cooked when in an unripe state in a way similar to that in which okroes are treated. They are then eaten in soup in the same way as garden eggs. When ripe they turn red like tomatoes and contain the black seeds by which the plant is propagated.

CUCUMBER [CUCUMIS SATIVUS]

The cucumber is a European vegetable which is sometimes grown in the gardens of Europeans in West Africa, or sometimes in school gardens. It is often attacked by small beetles which destroy the leaves before the fruit is properly formed. This can be partly prevented by the use of a stomach poison such as arsenate of lead. The cucumber does better in the cooler parts of West Africa, fruits of one foot or more in length

being sometimes produced. For further details of its culture the reader is referred to European and American books of agriculture.

CHOW-CHOW or CHAYOTE [SECHIUM EDULE]

The chow-chow is grown in a few parts of West Africa. It has a large root-stock, rather like that of a yam, which is very starchy. Starch, said to be a suitable substitute for arrowroot starch, can be obtained from it.

The stems are annual. They are creeping and the leaves are heart-shaped and lobed. The flowers are yellow, the male and female flowers growing at different parts of the same plant. The fruit is generally pear-shaped, 3 to 5 inches long, and contains one large seed. The flesh is edible and the young leaves are also edible and can be eaten like asparagus.

This useful West Indian vegetable has been grown successfully in West Africa, and should be more widely used.

It is propagated by planting the whole fruit at stake, and it requires stakes up which to grow.

THE SOLANUM FAMILY [SOLANACEAE]

Vegetables belonging to this family all have flowers of very much the same structure, and possess distinct tap-roots. They are all grown for their fruits, namely tomatoes, garden eggs, and peppers.

TOMATO [LYCOPERSICUM ESCULENTUM]

This plant is an annual, growing as high as 4 feet, and with deeply divided strongly-scented leaves. The flowers are yellow and the fruits red and spherical. The tomato thrives in most districts and grows best in a rich well-drained loamy soil with a moderate rainfall.

It is propagated by seed, being sometimes planted at stake, but generally sown first in flats or boxes or in special nursery beds where the seedlings are often protected from the strong sun by palm-leaf shades. In some districts farmers grow their tomatoes for an 'early' market, that is, they try to raise plants which will bear fruit some weeks before the main crop comes in, thereby gaining a higher price. Small and specially shaded nursery beds are prepared either in a low-lying rich and moist place, or near water, or else they may be made in the compound and near the water-supply. The seeds are sown either towards

the end of the dry season or at the beginning of the tornado season, and carefully watered. The young and healthy plants are transplanted later into their permanent positions, which are usually about 3 feet apart.

Tomatoes are comparatively easy to grow. Great care should be taken, however, to see that all parts of the plant have a full share of light and air. They are generally allowed to trail freely on the ground, but where better fruits are required, as in school gardens, it is best to train the plants up stakes, tying them with raffia fibre or string. This keeps the fruits off the ground where they are more liable to rot and be attacked by boring insects. Stake-trained tomatoes can be pruned easily, and as the young side-shoots appear in the axils of the leaves they can be pinched out with the fingers and the whole plant trained to produce only one or two main stems. By pruning tomatoes in this way fewer but larger fruits can be obtained.

The common tomato grown in West Africa is small and round and is produced in great quantities on the plant. Some of the fruits are misshapen and deeply wrinkled. European and American varieties usually produce fewer but larger fruits, which are generally of a better shape. These introduced varieties are much less hardy than the local African types and are more easily attacked by leaf-diseases and insect pests which attack both leaves and fruits. Caterpillars which attack tomato plants in this way can be checked by sprinkling arsenate of lead powder over the leaves and fruits, but as it is poisonous, care should be taken to wash off the powder before the fruit is eaten.

Tomatoes are a good example of the necessity of a regular water supply, for if after a period of drought they are watered excessively, a disease known as 'blossom-end rot' occurs, which causes the fruits to rot and turn black at the blossom-end of the fruits. Ripe tomatoes can be eaten alone, or sliced and eaten with bread and butter. In West Africa they are usually eaten in soups.

The seeds should be carefully dried and stored, as they soon lose their vitality.

GARDEN EGG, EGG PLANT [SOLANUM MELONGENA]

Garden eggs are usually annual plants, although some varieties may live into a second season. They are low bushy plants, generally about 2 feet high, with large leaves, purple or whitish flowers, and large fruits with a shiny skin. The shape and colour

of the fruit may vary greatly; though it is occasionally lobed, it is generally oval. Some varieties are white, others cream-coloured or yellow, others bright orange and others again, dark purple.

Garden eggs are grown throughout West Africa and do well in most soils, although they do best in rich, well-drained loams with a moderate rainfall. They are usually sown in specially prepared nurseries, and planted out later, in rainy weather, to their permanent positions which are 2 feet 6 inches to 3 feet 6 inches apart. Some farmers sow the seed at stake. After three months' growth the plants begin to produce fruit and continue to bear for three months or more. They are very hardy and are attacked by few pests.

The fruits are generally picked when they are sufficiently grown, and are eaten in soups. They have a somewhat bitter flavour, to which it takes some time for a European to become accustomed.

One imported variety, the 'Black Beauty' garden egg, produces enormous shining purplish-black fruits. In the United States these fruits are cut into slices like bread, fried in oil and eaten as a very palatable vegetable, and more use could be made of them in West Africa in this way.

PEPPERS [CAPSICUM ANNUUM and CAPSICUM FRUTESCENS]

1. *Capsicum annuum.* **Capsicum Pepper.** The varieties of this plant are usually shrubby in growth, reaching a height of 2 feet or more. Although usually annuals like garden eggs, they sometimes last into a second season and start growth again.

The leaves are oval and the flowers are small and white, greenish-white or pale yellow in colour. The fruits vary greatly in size and shape, being sometimes small and pointed, small and blunt, narrow and blunt, broad and blunt, large and blunt, or long and cylindrical. (Fig. 25.) There are several clearly defined varieties in West Africa which are distinguished mainly by the shapes of their fruits. Most of the varieties have green fruits when unripe, but when ripe they may be either white, pale yellow, orange, purple or bright red. Most of them are bright red when mature.

Peppers are propagated by seeds which are sometimes sown in special nurseries and the seedlings transplanted to permanent positions 3 feet apart later on, or the seeds may be sown at

stake. After about three months of growth they come into bearing and produce fruits continually for six months or more. Some varieties survive the dry season and continue to bear fruits in the following season.

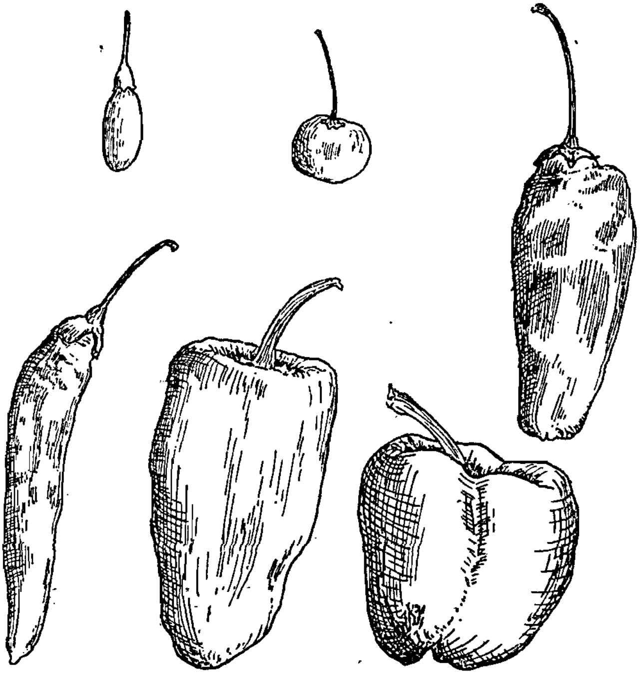

FIG. 25. Varieties of pepper. (Capsicum.)

Peppers thrive in most districts and under varying soil and climatic conditions in West Africa. The best peppers are grown in regions of moderate rainfall in rich well-drained soils.

There are several varieties that have been imported into West Africa, mainly from the United States. These imported varieties generally have much larger fruits than the local varieties, and are not so hot to the taste. They are usually picked in the green state when they are known as 'sweet peppers'. Sweet peppers, when sliced, can be eaten raw or in vegetable salads.

In America they are generally 'stuffed' with mince and bread-crumbs and chopped tomatoes and onions and cooked, after which they are served as 'stuffed peppers'. In this form they are not too hot to the taste and are pleasant and nutritious to eat, and should be more widely used than they are.

Generally speaking, the different varieties of pepper are much 'sweeter' and milder when in the green state, but when ripe, or when they turn red, they are very hot, some varieties being much hotter than others. It is in the ripe or 'hot' form that West Africans prefer them, and probably all tribes grind them up and use them for flavouring their soups and stews, which are almost always very hot. The hot fruits of some varieties are used in African herbal medicine.

2. *Capsicum frutescens*. **Chile Pepper.** This plant, which is a perennial, is more shrubby in growth and has smaller leaves and fruits than *Capsicum annuum*. The fruits are generally small and pointed and are also hotter than other peppers and are the type generally used in African medicine.

The Chile pepper is sometimes called the 'bird pepper' as its small seeds are occasionally used commercially for feeding birds. In West Africa it is especially loved by a bird known as the black-capped bulbul, although this and other birds also eat the ripe fruits of *Capsicum annuum* as well.

Capsicum frutescens, although often grown on farms or in compounds, is also found growing wild owing to the dispersal of its seeds by birds.

The ripe, red fruits of both *Capsicum annuum* and *Capsicum frutescens* are dried and used in certain parts of the world in the preparation of a spice known commercially as 'Paprika' and 'Cayenne' pepper. In commerce the larger fruits are known as 'Capsicums' and usually come from *Capsicum annuum*, whereas the smaller and hotter fruits are called 'Chillies' and come from *Capsicum frutescens*. These dried fruits are ground into a red powder which is known by the above commercial names, Cayenne pepper consisting chiefly of *Capsicum frutescens*. It is very hot, like the pounded peppers put into West African soups, and is hotter than the common black or white pepper sold in stores.

These red peppers must not be confused, however, with the common pepper of commerce which comes from an entirely different plant, which is a climber in the forests of South India and closely resembles the West African forest creeper *Piper*

guineense. This Indian climber, which is known as 'black pepper' (*Piper nigrum*), is grown commercially in the East Indies, and the dried berries are ground into a powder which is the 'pepper' usually sold in stores to Europeans. If the dark outer covering of the berries is removed before grinding, a product known in commerce as 'white pepper' is the result.

CHAPTER XXVI

SHALLOT. ONION. GARLIC. OKRO. SORREL. SPINACH PLANTS

THERE are two main kinds of onions grown in West Africa: the common small onion which is in reality the shallot, and the large onion grown in Northern Nigeria.

THE SHALLOT. 'MULTIPLIER' ONION

[ALLIUM ASCALONICUM]

A bulbous herb producing several bulbs round the base of the original one. The leaves are bluish-green and hollow. The shallot seldom produces flowers or seeds under cultivation, and the mature bulbs are about 1 inch in diameter.

It is propagated by bulbs and grows best in a rich, sandy loam soil with a moderate rainfall. Only the best bulbs should be selected and after being cut across the top to induce the production of shoots, they are placed in the soil with care, so that the apex is just above the surface. The soil must be well cultivated and reduced to a fine tilth before setting the bulbs, and if possible should be manured first with well-rotted compost or farmyard manure. Poultry manure is specially rich and suited for onions, which respond well to manuring. They should be planted in rows about 1 foot apart, with 6 to 8 inches between the bulbs in the rows. They require little care beyond weeding and surface cultivation whenever the soil becomes caked or hard after each rain and during the dry weather. As they mature the leaves turn yellow and fall over, and the bulbs are then harvested in dry weather and are left lying on the soil for a time so that the outside layers may dry thoroughly before they are stored. Where possible the bulbs should be dried on racks, with an undercurrent of air and some protection from the sun. They are usually strung into ropes and sent to market. If they are to be stored, they must be thoroughly dried first and then kept in a dry store and spread out thinly on racks or shelves which will permit free access of air. If the bulbs are heaped together it causes sweating and encourages the growth of moulds which will lead to decay. The bulbs should be examined at frequent intervals and all defective bulbs removed.

Two crops are generally raised in a year.

Shallots are used to a great extent in West African cookery; generally in soups or mixed with peppers and eaten with fish.

Pickled onions are prepared in Ga districts of the Gold Coast. The vinegar in which they are soaked is made from palm wine which has become sour and to which peppers are added to give a hot flavour.

ONION. 'SPRING ONION' [ALLIUM CEPA]

This plant differs from the shallot mainly in that its bulbs do not 'multiply' round the base, and also because its bulbs are much larger, being 3 to 6 inches in diameter. The leaves are also bluish-green and hollow. It generally flowers and seeds freely.

The bulbs are firm-fleshed and resemble the common European onion in appearance. There are at least three varieties: white-skinned, red-skinned, and purple-skinned.

This onion is grown mainly by the Hausas of Northern Nigeria, who grow it under an intensive system of agriculture near their towns, and the large onions sold in the markets of coastal towns in the Gold Coast and Southern Nigeria are generally of Northern Nigerian origin.

It is generally propagated by seeds in Northern Nigeria, but can also be propagated by the bulbs, which are first sliced across the top, thereby producing six to ten or more shoots. The culture of these onions is a highly specialized business and has not spread as yet to the tribes of the Coast, where it may be that the more humid climate does not suit it so well.

Holland suggests that virile seeds of this plant could well be introduced from the Canary Islands, so that proper onions could be grown to a far greater extent in West Africa.

GARLIC [ALLIUM SATIVUM]

Garlic is a bulbous herb, mainly distinguished by its flat leaves from the shallot and onion which have hollow leaves. The bulb itself consists of numerous wedge-shaped bulbs, surrounded by a white fibrous skin.

The method of culture is practically the same as that of the shallot.

Garlic is used more for seasoning than for food in West Africa. The bulbs are ground up and used as a flavouring in cookery and have a strong taste. They are also used in African medicine.

MALLOW FAMILY [MALVACEAE]

OKRO [HIBISCUS ESCULENTUS]

The okro is an Indian plant now naturalized throughout the tropics and in parts of the sub-tropics as well. It is an erect plant growing to 4 or 5 feet in height, although some varieties are shorter and more spreading. The leaves are large and are generally riddled with holes made by insects. The flowers are large and showy, and are yellow with reddish or purplish centres. The fruits are generally long and pointed at one end, although some varieties are short and blunt. (Fig. 26.)

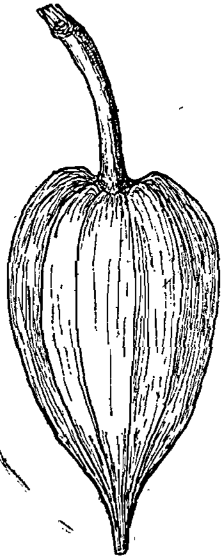

FIG. 26. Broad-fruited okro.

The okro is grown as a vegetable crop on almost all West African farms. It is propagated by seed which is planted at stake, the best distance being 3 feet between the rows and 2 to 3 feet between the plants in the rows, the distance apart depending on whether the variety planted is tall or short and spreading.

Okro thrives in most soils, provided they are not too water-logged, and good crops of it can be raised on the dry coastal plains of the Gold Coast, sometimes in quite sandy soil behind the sea beach, where the soil is also rather salty and unsuited to the growth of most other agricultural crops.

Three or four seeds can be sown in each hole, and the young plants can be thinned out later to one plant per hole. With tall-growing varieties it is often useful to pinch off the top shoot when the plants are about 1 foot high, as this causes them to become more spreading. They come to maturity generally three or four months after sowing and continue to bear fruits for several months afterwards, until the dry weather comes and the fruits become woody and fibrous, when it is best to allow them to set seeds. Some quick-growing varieties produce fruits as soon as two or three months after sowing.

Okroes are generally planted in the main rainy season, but quite good crops can often be raised in the small rains as well.

The okro is one of the most useful of African vegetables. It is eaten in soups by most tribes, and a special soup with a basis of okroes, and known as 'okro soup', is sometimes prepared. The fruits are mucilaginous and for that reason are excellent for thickening soups, as well as being of considerable food value.

The fruits are sometimes sliced and dried, or ground to a powder, and then sold in markets.

The seeds, when roasted, have been suggested as a substitute for coffee.

The dried fruits should be carefully stored, the seeds extracted from them and then kept in air-tight tins until the following planting season. In some parts there is a considerable trade in dried fruits, the seeds of which are used for planting.

The tender leaves of the okro are sometimes boiled and eaten as spinach. The dried flowers are eaten in soup by certain tribes of the Northern Territories of the Gold Coast. The stems contain a fibre which can be used for domestic purposes and which is of considerable strength.

SORREL [HIBISCUS SABDARIFFA]

The sorrel plant grows to a height of 3 feet or more and is erect in habit and slightly branched. The stem is sometimes reddish in colour, particularly as the plant grows older. The leaves are lobed and the flowers are yellow with dark centres. The fruits are fleshy when young and have a fleshy calyx and epicalyx beneath.

This plant is often grown as a vegetable by the Hausas and by various tribes in the Northern Territories of the Gold Coast. The leaves have a pleasant acid taste and can be used as a vegetable. It is the fleshy calyx and epicalyx which are generally used as a vegetable in soups and sometimes as a beverage as well.

In the West Indies and elsewhere in the tropics this plant is known as 'roselle', and jams and jellies are sometimes made from the calyx.

The stem, like that of other species of *Hibiscus*, contains a strong fibre.

The seeds contain oil and are used as food either in soups or in cakes in the same way as Dawadawa (*Parkia filicoidea*).

SPINACH PLANTS

There are at least twenty-five different kinds of plants in West Africa of which the leaves or young shoots are eaten. The

leaves of such plants when boiled are generally known as 'spinach', or sometimes as 'pot herbs'. The term 'spinach', then, may apply to any plant with edible leaves. The great majority of West African spinach plants grow wild and the leaves are picked only as they are required. A few of them are sometimes grown on farms or in compounds, and the three best known cultivated ones are *Basella alba*, *Amaranthus caudatus*, and *Corchorus olitorius*.

Indian Spinach [BASELLA ALBA]

This is a climbing plant with fleshy green leaves which are almost triangular in outline. (Fig. 27.) The flowers are small and pinkish and the fruits are small and round and filled with a black juicy pulp which stains like ink.

This plant is of American origin, but is grown so widely in India that it is known as 'Indian spinach'. It has been introduced into West Africa in comparatively recent times and is gradually spreading, as it is probably the finest quality spinach and approaches nearest to European spinach (*Spinacia oleracea*) in flavour.

Indian spinach thrives in most soils and will grow even in dry coastal districts, although it does best in rich, well-drained soil with a moderate rainfall. It is propagated by planting the fruits whole, or it may be propagated by planting pieces of stems (soft-wood cuttings) in damp soil in wet weather.

As it is a creeper it is sometimes trained up a trellis-work which can readily be made from bamboos or sticks. In African compounds it is often trained up fences or over arbours. The main advantage of training it up off the ground is that the leaves do not become covered with dirt and can be cleaned with little difficulty before being eaten. On the other hand, if the stems are allowed to grow long, the plant produces smaller leaves and tends to run to seed and die out more quickly, whereas if it is continually kept cut back to a height of 6 inches it produces larger leaves and lasts longer.

Indian spinach lasts for months and the leaves can be picked continually while the plant produces new ones.

Amaranthus caudatus

An erect annual herb, growing to 2 or 3 feet in height. The leaves are light green with prominent veins on the lower surface. The flowers are small and greenish white and are produced in great masses at the top of the plant.

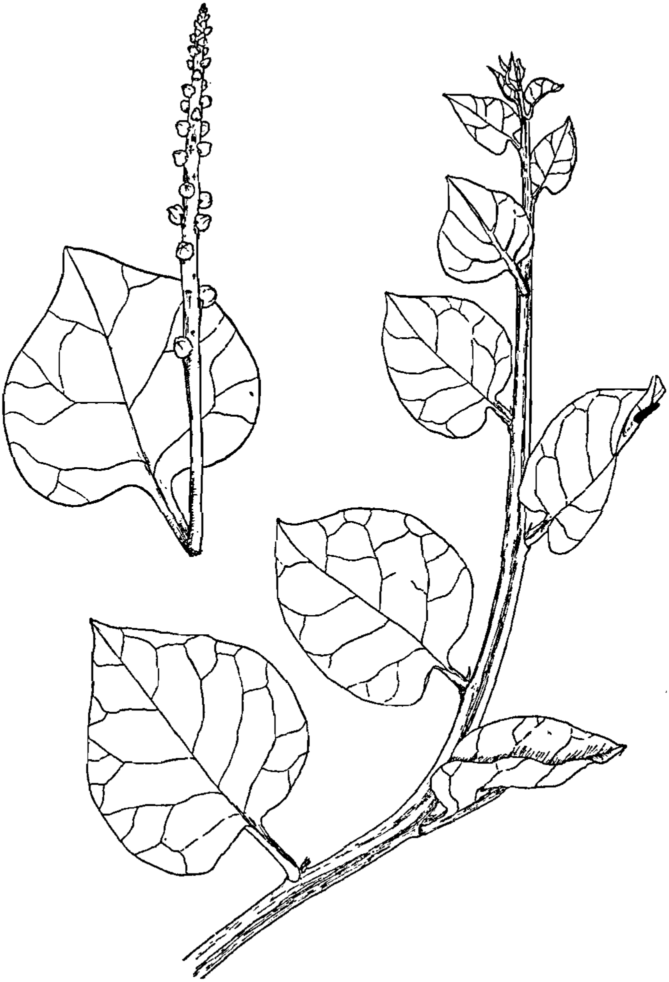

FIG. 27. Indian spinach (*Basella alba*).

There is also a variety of this plant with red leaves, which sometimes reaches a height of 4 feet or more, with its clusters of tiny flowers hanging down in crimson tassels from the top of the

plant, which is grown in English gardens for ornamental purposes under the name of 'Love Lies Bleeding'.

Both the green and red varieties are eaten as spinach and are propagated by the numerous tiny seeds which they produce. They are generally grown in African compounds or on small farms or 'kitchen gardens' near compounds or villages. The leaves afford one of the best qualities of African spinaches.

Jew's Mallow [CORCHORUS OLITORIUS]

A woody herb 2 to 3 feet high. The leaves are oval or narrowly oval, 6 to 8 inches in length and 2 inches broad. The flowers are yellow and the fruits 1 to 2½ inches long, 5-valved, and narrowing abruptly at the tip.

This plant is grown by the Yorubas and Hausas of Nigeria, by the Ewes of Togoland, and in parts of Sierra Leone as a spinach plant, and should be grown more universally in West Africa than it is. It thrives in most soils and the leaves afford a good quality of spinach.

The stems contain a fibre which is used as jute in India, but it is not of quite such good quality as the fibre from the commercial Jute plant (*Corchorus capsularis*) which is also grown mainly in India.

The leaves of several cultivated and uncultivated plants are eaten as spinach, notably the bottle gourd (*Lagenaria vulgaris*), red-flowered silk cotton tree, baobab, pumpkin, okro, sweet potato, cassava, Lima bean, cow pea, gingelly (*Sesamum indicum*) and the delicate leaves of the coco-yam (*Xanthosoma sagittifolium*). (For a list of some of the wild plants whose leaves are used as spinach cf. the author's *Plants of the Gold Coast*, pp. lviii–lix.)

CHAPTER XXVII

EDIBLE LEGUMES

GROUND-NUT. BAMBARRA GROUND-NUT. GEOCARPA GROUND-NUT. PIGEON PEA. COW PEA. SWORD BEAN. LIMA BEAN. 'JERUSALEM' PEA. SOYA BEAN. YAM BEAN

'EDIBLE legumes' is the term applied to those members of the pea or bean family (*Leguminosae*) which bear fruits or seeds which can be eaten. This legume, or pod-bearing family (*Leguminosae*), is a very large one in West Africa and is divided into three sections according to the structure of the flower. All bear pods or legumes, and one section of them has flowers like those of peas and beans and is said to be 'papilionate', that is with flowers somewhat resembling butterflies with outstretched wings.

To this section of the leguminous family, known scientifically as the *Papilionaceae*, belong various herbs of food value to man. The commonest ones in West Africa are:

1. The ground-nut (*Arachis hypogea*).
2. The Bambarra ground-nut (*Voandzeia subterranea*).
3. The Geocarpa or Hausa ground-nut (*Kerstingiella geocarpa*).
4. The pigeon pea (*Cajanus Cajan*).
5. The cow pea (*Vigna unguiculata*).
6. The sword bean (*Canavalia ensiformis*).
7. The Lima or butter bean (*Phaseolus lunatus*).
8. The 'Jerusalem' pea. (Probably *Phaseolus trinervis*.)
9. The Soya bean (*Glycine Soja*).
10. The yam bean (*Sphenostylis stenocarpa*).

All these crops could be grown as green manures, but only a few of them, such as the cow pea, the 'Jerusalem pea', the sword bean, and the pigeon pea, are used for this purpose as a rule.

1. THE GROUND-NUT [ARACHIS HYPOGEA]

This is an annual plant, probably a native of South America, growing to a height of 1 foot and generally spreading 18 inches or more along the ground. The leaves are pale green, compound, with four leaflets, and the flowers are golden yellow. After fertilization the petals fall and the flower-stalk elongates and

turns downwards until the tiny developing ovary is buried below the surface of the soil.

There are two main types of ground-nuts known, namely the 'bunched' and the 'running' types. The varieties of 'bunched' ground-nuts grow to a height of 1 foot or 18 inches, and do not spread far along the ground; whereas the 'running' varieties do not grow so high and their stems run along the ground for 1 or 2 feet or even more. Although 'bunched' varieties do occur in West Africa the 'running' varieties appear to be much more common. The 'bunched' types yield less but are more suitable for interplanting with other crops because of their habit of growth, whereas the 'running' types are generally the heavier yielders and are usually grown alone. The 'bunched' types require less labour to harvest, and there is need for the development or introduction of a 'bunched' type which is a heavy yielder. So far introduced varieties have failed to thrive as well as local varieties. Many of the varieties grown in America are of the 'bunched' type.

The ground-nut thrives in many parts of West Africa, notably in the Gambia, where it is the main export crop, and in Nupe country in Nigeria, where it is one of the main crops. Large areas of ground-nuts are grown for export in other parts of Northern Nigeria particularly in the Kano region. In many other districts of West Africa they are grown mainly for local use.

The main requirements of the ground-nut are a light or medium rainfall of between 30 and 50 inches, and plenty of sunshine. The soil should not be too stiff or clayey, as the plant will not be able to bury its fruits in stiff compact soil. Rich, sandy loam is the best, and if the soil is rich in lime, so much the better.

Only the best seed which has been carefully stored and kept as free as possible from moulds and insects, should be chosen. The seeds should be kept in the pods until they are required for sowing. When removed they should be planted with as little delay as possible as in this state they quickly lose their vitality. Ground-nuts can also be planted in the 'shell', and it is often easier to plant them in this way, especially if large areas are to be sown. Some farmers just crack the shell which is then planted with the seeds inside. The main disadvantage, however, is that it is impossible to know whether all the seeds are large or healthy until the shells have been broken and the best seeds selected, although this is generally a slow and laborious business.

It is best to sow three or four seeds in a hole. The holes should be roughly 3 feet apart and with 3 feet between the rows. The soil should be dug deeply first and all weeds removed or buried. Planting is done at the beginning of the rains and replanting is often necessary as the seeds are often dug up by crows. These are best kept away either by shooting the wily birds and tying up the bodies in conspicuous places on the ground-nut farm, or by fixing up a 'scarecrow' consisting of an upright pole with a cross-pole attached, on which old clothes are put in such a way as to resemble a man.

The ground-rats and ground-squirrels which dig up and eat the seeds are more difficult to deal with. They also disturb the young developing seeds and can best be dealt with by setting traps.

During growth the soil should be kept free from weeds and thoroughly loosened so that the flowering stalks can easily bury themselves underground. Some farmers actually prick down or tread upon the central shoots, which are then covered with soil, in the belief that this will enable the plant to have a larger yield.

One of the advantages of the ground-nut is that it forms an excellent cover crop and keeps the soil damp underneath. It is an excellent catch-crop also, when planted in the interval between two long standing crops in a rotation.

As the plant is reaching the flowering stage it is sometimes attacked by a disease known as 'mosaic'. This causes the leaves to turn pale yellow in places so that they have a mottled or mosaic appearance. The leaves decrease in size and the whole plant becomes dwarfed and bunched. The disease sometimes attacks one part of the plant first, or it may appear on all parts simultaneously. Almost invariably it causes the plant to wither and die, and the disease spreads throughout the whole ground-nut farm. It is worse in some seasons than in others and sometimes kills off 75 per cent. or more of the crop. The actual cause of mosaic disease, the way in which it is spread, and the method of treatment and cure are at present imperfectly known. The only steps to be taken against it are to choose the healthiest seeds from plants that have not been affected, and to pull up and *burn* any plant as soon as it shows signs of the disease, which helps to prevent it spreading. In certain seasons the weather conditions appear to favour its spread, so that in such seasons, apart from burning all infected plants, it seems impossible to prevent the

loss of the major portion of the crop. Early planting seems to be the best method known of reducing the effect of the disease to a minimum.

Rotation is very important with ground-nuts, as mosaic will spread rapidly if the plants are grown twice or more on the same piece of land. For this reason ground-nuts are suggested as a suitable rotation crop with cotton, corn, Guinea corn, and other crops suitable for growing on light soils with a fairly dry climate.

The ground-nut takes three to five months to reach maturity, depending mainly upon the season, soil, or other local conditions. In regions of two rainy seasons in the year two crops can generally be raised.

As the fruits ripen, the stems and leaves wither and die. The fruits are then carefully dug up in dry weather (Plate XXX *a*), the soil is shaken off them, and they are left on the surface of the soil for a day or two to dry. They are picked, thoroughly cleaned, and dried in the sun, and stored in dry, air-tight, and rat-proof containers.

Sometimes in the Gambia the ground-nuts, after being pulled, are dried in 'stacks' on raised platforms before being thrashed. (Plate XXX *b*.) The best pods should be selected and set aside as seed, and the remainder either prepared for home use or sold.

In the Gambia, where large quantities of ground-nuts are grown, they are sold and exported in their husks, that is, in the 'undecorticated' form. In certain other parts of the world the seeds are shelled or 'decorticated' first and then exported to Europe where they are mainly used in the manufacture of ground-nut oil.

Ground-nuts from Southern Nigeria have shells of a dirty greyish colour, whereas those with straw-coloured shells are preferred in Europe. As the kernels of the Southern Nigerian ground-nuts are satisfactory, however, it is an advantage to ship them in a shelled or decorticated state as is done in Northern Nigeria. The seeds are removed from the shells either by pounding them in mortars or with sticks.

The oil obtained from undecorticated West African nuts is of the best quality and is used in making margarine, as a substitute for olive oil in cookery, as a salad oil, for packing sardines, and for other purposes for which the more expensive olive oil is generally used. Both Europeans and Africans use ground-nut

oil for cooking purposes. The oil from the decorticated seeds is generally used in soap-making.

In both decorticated and undecorticated nuts the best oil is first obtained by simple pressure (cold pressed oil), whereas oil of inferior quality is obtained by further pressure and heat and is used mainly in soap-making.

The resulting residue after most of the oil has been expressed is known as 'ground-nut cake' and is used in feeding dairy cattle in the same way as palm kernel and coconut cakes, except that ground-nut cake is richer in proteins. Ground-nut cake is generally combined with other cakes in the manufacture of compound cattle cakes.

In France the empty ground-nut shells are ground up, mixed with molasses, and used as a cattle food.

In America the seeds are pounded into a paste known as 'peanut butter'. This is a nutritious food, eaten with bread, and is practically the same as the ground-nut paste which West Africans prepare by grinding the seeds in the preparation of ground-nut soup. Ground-nut soup, a favourite food in most parts of West Africa, is very nutritious, as it is rich in oil, proteins, and carbohydrates.

In Northern Nigeria ground-nut oil is extracted from the seeds by primitive means, and is used in cooking and as an illuminant. The Hausas also make a food consisting of balls like doughnuts, or rings, made of ground-nut paste fried in oil. The seeds are also eaten raw in all parts of West Africa, or they are often eaten roasted. To remove the thin red parchment around the seeds they are generally stirred gently in a large iron or earthenware pot in which some sand has previously been put, until the 'skins' are parched, after which they crack easily and are rubbed off with the hands.

Ground-nut oil is used on the Gold Coast as a mild purgative. In large quantities it is occasionally used in making soap.

The stems and leaves, after the fruits have been picked, should be dug into the soil again as manure; so that ground-nuts grown in a rotation help to enrich the soil as well as to afford food. In the green state the leaves and stems form an excellent fodder for live stock; while if they are specially dried and made into hay they are also useful as fodder for cattle and horses. Ground-nut hay is of high nutritive quality and is used by the Hausas in the dry season when fodder is difficult to get.

2. BAMBARRA GROUND-NUT

[VOANDZEIA SUBTERRANEA]

The Bambarra ground-nut is a small herb growing to 1 foot in height, with compound leaves consisting of three leaflets. The flowers are produced in pairs and the fruits are formed underground, generally in one- or two-seeded pods, although there is one variety which bears three-seeded pods. The fruits are rounded, wrinkled when dry, and almost 1 inch in diameter. The seeds are about ½ inch in diameter, practically spherical, smooth and hard, and vary greatly in colour, being either black, white, yellow, red, brown, or mottled with various colours.

The Bambarra ground-nut is grown in very much the same way as the ground-nut, and does well in sandy loam soils with a light rainfall. It is grown on the coastal plains of the Gold Coast and in parts of Northern Nigeria and in other parts of tropical Africa. The planting distances and cultural directions are practically the same as those of ground-nuts, except that this plant does not spread so much and is much 'bushier' in growth and, as a rule, only covers 12 or 15 inches of ground. It is ready for harvesting four or five months after planting.

The seeds, unlike those of the ground-nut, cannot be eaten raw, but must be cooked first. They contain a much lower percentage of oil (only 6 per cent.) so that they are of no value for the production of oil. Their high percentage of carbohydrates (58 per cent.), and albuminoids (a form of proteins) 16 per cent., shows that they are nevertheless of distinct food value. They are cooked and prepared in various ways, being sometimes boiled and then crushed into cakes or balls which are then fried in palm oil, sometimes with peppers or salt added. The latter food keeps better and longer than the ordinary boiled cakes made from these seeds.

Fresh Bambarra ground-nuts form an excellent vegetable when boiled, resembling Lima beans in flavour.

3. GEOCARPA, HAUSA or KERSTINGIELLA GROUND-NUT

[KERSTINGIELLA GEOCARPA]

This is an annual herb in some respects resembling the Bambarra ground-nut. The leaves are compound with three leaflets which are obovate, that is, broader at the tip than at the base, and more or less rounded at both ends. The fruits, like those of the ground-nut and Bambarra ground-nut, are buried below

the soil when young, but the pod is of a different shape, and instead of being cylindrical or round, is flattened, and about 1 inch long, wrinkled on the outside, and one- to three-seeded. Where there are two or three seeds in the pod it is constricted or narrowed between each seed. The seeds are somewhat flattened and kidney shaped, about 1 cm. in length, a rich brown or black colour, and with a scar near the centre.

The details of its soil and climate requirements and its methods of cultivation are more or less the same as those of the ground-nut and Bambarra ground-nut. It is sown in the middle of the rains, May or June, and harvested four or five months later.

It is edible and of good food value, and has been recommended as a suitable food for Africans as well as for Europeans living in West Africa.

It is grown in Dahomey, Northern Nigeria, the Northern Territories of the Gold Coast, and in other dry parts of West Africa, where it is prepared as food in different ways. The Dagomba tribe of the Gold Coast remove the testa or seed-coat by beating the seeds in a mortar. The kernel is boiled, salt and shea-butter are added, and the whole is then eaten. They grow this crop amongst their maize and millet.

4. PIGEON PEA or CONGO PEA [CAJANUS CAJAN]

The pigeon pea is a shrub growing to 6 feet or more in height, and of erect habit. The leaves are compound, with three leaflets which are covered with short velvety white hairs. The flowers are yellow with reddish veins and the pods are short and flat and generally contain three to five seeds. (See Fig. 28, p. 273.)

The pigeon pea is believed to be a native of India, but is grown in most parts of the tropics. It does best in a deep, rich, sandy loam or loamy soil in a fairly dry climate, as in a damp climate the pods and seeds tend to be attacked by moulds.

It is propagated by seeds, which are best planted in rows as far as 8 feet apart, with 8 feet between the plants in the row. By such wide planting much heavier crops of beans are produced. If planted closer only the plants on the outside rows yield heavily. After weeding and cultivation of the soil in the earlier stages of its growth, it rapidly forms an excellent cover, in the shade of which few weeds can survive. After four to six months' growth it produces fruits, and the young undeveloped green seeds, if picked and eaten at this stage, are very nutritious

and form an excellent substitute for English green peas, which cannot be grown properly in most parts of West Africa.

If the pods are left too long without being picked they are generally attacked by the larvae of certain insects, which bore into the ripe seeds and destroy the greater part of them. Care should always be taken therefore to keep picking the pods continually as they ripen, instead of leaving them on the plants. After being harvested in this way, the seeds should be removed from the pods, as any larvae in them quickly spread unnoticed when the dried pods are stored. The shelled seeds should be examined carefully, and all infested ones removed, and the remainder, consisting of apparently healthy ones, should be packed in air-tight tins. As a few larvae are still likely to exist, unobserved, in some of the seeds, and will quickly spread in the seed-tin, carbon bisulphide should be added and the tin sealed.

After fruiting, the plants should be cut down to within a foot or so of the ground and in the following rainy season they quickly grow new branches bearing flowers and a second crop of seeds. Unless they are pruned in this way at the end of their first year of growth, they do not produce such a good crop in the second year. After the second year's growth they can be pruned again, when a much smaller crop is produced in the third year; after this the plants should be destroyed. It is usually not worth growing pigeon peas for more than two years on the same piece of ground. The woody stems, when dried, form an excellent firewood, and the leaves are shed continually so that a good layer of leaves forms beneath the plants and considerably enriches the soil.

The deep root system of the pigeon pea also improves the soil considerably by opening it up to a greater depth, as the tap-root penetrates quite deeply into the subsoil; and, since it is a leguminous plant, it also adds nitrogen to the soil.

The seeds of the pigeon pea are used as human food in India, where they are called Dhal and resemble the 'split peas' sold in stores and used for soups. Dhal is a nutritious food and is eaten on a large scale in India and could be eaten in West Africa also if more was known about its method of preparation. When green and unripe the seeds can be cooked and eaten like 'green peas'. When ripe the seeds need to be soaked for twelve hours and then thoroughly boiled before they are eaten, and they can also be used in soups and are of good nutritive value.

The seeds are also useful as fodder for horses and other

animals, and the pods can be used in the same way. The foliage is also of value for feeding live stock, and at Achimota sheep and goats are 'folded' on areas of pigeon peas and thrive well on it. The goats seem to like them even better than the sheep do.

The seeds can be ground up or broken into small pieces, either in a small grinder, or mill, or 'cracked' by pounding in a mortar, after which they are fed, along with cracked corn, to poultry. They are richer in proteins than cracked corn.

5. COW PEA [Vigna unguiculata]

This is an annual plant with smooth creeping stems and compound leaves with three leaflets. The flowers vary greatly in colour, being white with a purple tinge, pink, yellow, or red. The pods are about 6 inches long and thin and almost cylindrical.

The cow pea thrives in most parts of West Africa, and in rich soils with a good rainfall it tends to produce a mass of foliage at the expense of seeds. In a good loamy soil with an average or fairly light rainfall it produces fruits and seeds three or four months after planting, and the stems and leaves form a thick cover which is sometimes dug in green as a green manure. Even if the seeds are picked first the withering foliage can be dug in to enrich the soil, or even if it is left, it forms an excellent cover at the beginning of the dry season and the leaves soon fall and enrich the soil, while the roots add humus and nitrogen to it.

The young tender leaves of the cow pea are eaten by certain tribes as spinach. The young green pods are suggested as a substitute for French beans.

The seeds are used as food in all parts of West Africa and are commonly seen in most markets. They are of various colours, white, red, yellow, or brown. Mottled seeds are sometimes also seen. Some authorities believe that the white-seeded variety is the best in quality.

The cow pea is used in various ways as food. The Hausas use the pods, after the seeds have been removed, as a fodder for cattle. The seeds are generally boiled and eaten or put in soup or made into special/pea soup. Sometimes they are pounded when dry and made into a kind of pea meal which is cooked in various ways, generally in the form of balls or doughnuts, which are eaten in or with soup or fried in oil. The pea meal is sometimes made into a form of porridge.

Cow peas are grown extensively in the sub-tropics also, and in the United States they are used as a cover crop and green

manure and also as a fodder crop for domestic animals. In West Africa they could be used for these purposes far more than they are used at present.

(For further details of cow peas cf. chapter on 'Leguminous Green Manures and Cover Crops'.)

6. SWORD BEAN [CANAVALIA ENSIFORMIS]

The sword bean is an annual plant, some varieties being low and bushy, and others climbing. The leaves are compound, consisting of three leaflets. The flowers are large, either pink or purple or white with a red base. The pods are large and sword-shaped, from which characteristic this plant has derived its name. They grow to a length of 1 foot and are flat with two longitudinal ribs along their upper edge. The seeds are smooth, elliptical, and tough skinned, and are white, red, or yellowish-brown.

The sword bean is grown throughout the tropics and thrives in most soils and under most West African climatic conditions. Good crops can be grown in light loamy soil with a rainfall as low as 25 or 30 inches.

The young and tender pods can be eaten as a green vegetable like French beans, and are cut into thin slices and boiled. The young immature seeds are rather coarse for human food, as the seed-coat is so tough that the beans need to be thoroughly soaked and the seed-coat removed before they can be eaten. They are sometimes put into soups.

(For further details of sword beans cf. chapter on 'Leguminous Green Manures and Cover Crops'.)

7. LIMA or BUTTER BEAN [PHASEOLUS LUNATUS]

This is an annual or biennial herb, generally a climber, but sometimes small and bushy with the stems woody at the base. The leaves are compound, with three leaflets, and the flowers are about 1 cm. long and covered with soft short hairs. The pods are generally three- or four-seeded, and the seeds are flat or slightly rounded. They may be white, black, red, brown, or mottled in colour. When the seeds are mottled the stripes radiate from the hilum to the outside edge of the seed.

The Lima bean is common on most African farms, and is generally interplanted with other crops. The leaves are sometimes eaten as spinach, and the plant can also be used as fodder for live stock.

The young pods can be eaten like French beans, and the young tender seeds are also very tasty. It is in the ripe stage, however, that the seeds are generally eaten. They are boiled and eaten whole, or pounded into balls prepared in various ways, or eaten in soup.

This plant is hardy and will thrive in most parts of West Africa and goes on bearing for several months.

It has also been recommended as a suitable green manure.

8. 'JERUSALEM' PEA [? PHASEOLUS TRINERVIS]

This is a strong creeping or climbing plant with hairy stems, compound leaves consisting of three large and hairy leaflets, and golden-yellow flowers. The pods are long and almost cylindrical, 6 inches or more in length, and very narrow, usually containing eight to twelve seeds, but sometimes more. The seeds are almost oblong in shape, very small, and are reddish-brown with a small white hilum.

The 'Jerusalem' pea is grown in some of the Agricultural Experimental Stations in West Africa, mainly as a green manure crop, but its seeds are edible.

It does well in a sandy loam or loamy soil in regions of medium or light rainfall, and takes from three to five months to mature.

The seeds are generally cooked in African soups and are of good quality, but have the disadvantage of being small and difficult to pick, so that large quantities must be gathered to make enough food for a meal.

Further details of the value of this plant can be seen in the chapter on 'Leguminous Green Manures and Cover Crops'.

9. SOYA or SOY BEAN [GLYCINE SOJA]

The soya bean is an erect plant with small violet or yellow flowers in clusters in the axils of the leaves, and oblong two- to five-seeded hairy pods. It deserves mention here, as it is of very great economic importance in other parts of the world and it has been grown with limited success in parts of West Africa. It is thought that one of the reasons for the comparative failure of Soya beans in West Africa is that the necessary soil organisms or bacteria required are missing (cf. 'Symbiosis' in Chapter V).

It may be sown either broadcast or in rows one and a half to two feet apart. It requires a rich, loamy soil, a moderate rainfall, good drainage, and a fair amount of lime, and the soil

should be kept thoroughly tilled during its period of growth. It should be harvested before it is quite ripe, otherwise the pods split and many of the seeds are lost. The seeds are oval in shape with a small hilum, and may be black, white, or yellow in colour, although seeds of other colours are seen.

The seeds are of great food value and are rich in oil, which is competing with cotton-seed oil in the world's markets. In China and Japan the beans are crushed and made into meal, or into a thin paste known as 'soya milk', both of which are of great value as human food, as the seeds are rich in oil and proteins as well as in starch. They can be cooked and eaten whole, or used in soups, and, if roasted and ground, they can be made into a beverage something like coffee.

After the oil has been extracted from the seeds, the residue is pressed into cakes, which are used for feeding cattle.

Soya beans can also be grown in West Africa as a green manure or cover crop, and is used for these purposes in the United States, but in those districts where it can be successfully grown its culture should be extended, as it is one of the most valuable leguminous food crops that can be grown in the tropics.

10. YAM BEAN [SPHENOSTYLIS STENOCARPA]

This is a climbing plant with a potato-like tuber containing starch, which accounts for its name of 'yam bean'. The leaves are compound, consisting of three large leaflets. The pods are long and narrow and flattened (Plate XXX *c*), with ridges along the edges like those of the sword bean. The seeds are slightly longer than broad and bluntly rounded at either end.

It is generally grown up poles in the same way as yams.

It is grown by the Ibos of Southern Nigeria, and also in the Benin district, and in parts of the Gold Coast as well.

The seeds are usually cooked and eaten in soups.

CHAPTER XXVIII

LEGUMINOUS GREEN MANURES AND COVER CROPS

LEGUMINOUS plants specially grown for soil improvement and generally dug in at the period of their maximum growth are called 'green manures'. 'Cover crops' are generally leguminous plants grown as a cover on farm land during one or more seasons. Some are therefore annuals and others are woody and perennial. Sometimes cover crops are allowed to grow on land over the dry season or are grown on a piece of land that is not required at the time, so as to prevent soil erosion and add plant food to the soil as well. They may also be planted as a cover for the ground between perennial crops such as coconuts or oil palms. The main difference therefore between a green manure and a cover crop is that a green manure is dug into the soil, whereas a cover crop is allowed to stand. The plants used as green manures or cover crops are therefore divided into two groups, annuals and perennials, the annuals being generally used as green manures and the perennials as cover crops.

The following is a list of some of the leguminous green manures and cover crops found most satisfactory in West Africa.

ANNUALS.
1. Bengal or 'Mucuna' bean (*Styzolobium aterrimum*).
2. Velvet bean (*Mucuna sp.*).
3. *Calopogonium mucunoides*.
4. Lablab bean (*Dolichos Lablab*).
5. Cow pea (*Vigna unguiculata*).
6. Miscellaneous annuals—'Jerusalem' pea (? *Phaseolus trinervis*), Sword bean (*Canavalia ensiformis*), *Centrosema* species, and others.

PERENNIALS.
1. *Crotalaria* (various species).
2. Java or Natal Indigo (*Indigofera arrecta*) and other species.
3. *Tephrosia candida* and other species.
4. Pigeon pea (*Cajanus Cajan*).

ANNUALS

1. BENGAL or 'MUCUNA' BEAN

[STYZOLOBIUM ATERRIMUM]

The Bengal bean is an annual plant producing long trailing stems and compound leaves consisting of three large leaflets. The pods are slightly curved and have raised ridges like veins and generally contain three to five black seeds with a conspicuous white hilum.

The Bengal bean has been grown on many Agricultural Experimental Stations in West Africa, particularly in Nigeria, where it is generally known by the name of 'Mucuna' bean. It is easy to grow and is propagated by seeds which are generally planted at the beginning of the rains in rows 3 feet apart. They germinate rapidly and form an excellent cover crop in the rainy season and quickly cover the ground with a mass of foliage, and, if dug in when flowering, they form an excellent green manure. Unfortunately they do not last well in the dry season, when they shed much of their foliage and most of them die.

The Agricultural Department of Nigeria recommend growing this plant amongst maize and Guinea corn, the seeds of which are planted first. After they are established, 'Mucuna' beans are planted in the same rows, and the climbing stems of the beans soon envelop the lower parts of the stems of the maize or Guinea corn. The beans are timed to be planted so that their foliage will not completely cover the cereal plants and so prevent their proper development and the harvesting of their seeds. After the seeds have been harvested, the beans come to their full development and soon completely cover the upright stalks of the maize or Guinea corn. Sometimes these stalks are bent over at 1, 2, or 3 feet from the ground and laid along the rows, and the beans continue to grow along them like a trellis, forming a dense mass of foliage.

This plant is suggested as a suitable green manure plant for West African school gardens, and is also useful when grown in between permanent crops, such as oil palms and cacao in their earlier stages when they benefit from a cover crop which is at the same time adding nitrogen to the soil.

2. VELVET BEAN

[MUCUNA SP.]

This plant closely resembles the Bengal bean in most respects. The main difference between the two plants seems to be that

the velvet bean has a pod covered with dark brown velvety hairs, whereas the pod of the Bengal bean is smooth. The seeds of the velvet bean, moreover, are generally mottled brown and white, whereas those of the Bengal bean are usually black.

The velvet bean is widely grown in the Southern States of America whence it has been introduced into the Gold Coast and Nigeria.

It forms an excellent cover crop in the rainy season and produces a mass of foliage like the Bengal bean, which it also resembles in the way in which it dies off in the dry weather.

The velvet bean is used in the United States as an excellent green fodder, as a silage crop, and as hay for live stock, particularly cattle, and in West Africa it could be used more in this way with good results. In America and South Africa it is planted amongst maize, up the stalks of which it climbs, and both are cut and used as a fodder for stock.

It is an excellent manure if dug in while in the green state and it forms a good cover crop between more permanent crops.

The seeds are unsuitable as food for man, but whole dry pods can be fed to pigs who do their own shelling and grinding. When the seeds are 'cracked' or broken into pieces they form good food for cattle, sheep, goats, and poultry. Live stock, especially pigs, do well when allowed to graze on growing velvet beans.

3. *CALAPOGONIUM MUCUNOIDES*

This is an introduced plant and is a climber or creeper with hairy stems, hairy compound leaves consisting of three leaflets, and pale lilac flowers, which are followed by small hairy pods containing several seeds.

As it bears such small seeds, great care must be taken when they are first sown. They are generally broadcast, and it is best to sow thickly, as so many seeds are washed away in heavy rains. If they are carefully looked after in the seedling stage and once become established on a piece of ground, they do well afterwards, and soon cover the soil with a mass of hairy creeping stems which root at the nodes. They form dense cover 1 foot to 18 inches thick on the surface of the soil with masses of leaves which form a thick layer of dead leaves as much as an inch in thickness on the ground. The thick cover formed soon smothers out all weeds.

As it roots at the nodes it is a better ground cover than 'Mucuna' beans, which tend to climb over everything, and the

older stems can be used for propagation. If these 'soft-wood cuttings' of *Calopogonium* are planted in wet weather and care is taken with them, the plant can be propagated in this way, but in drier climates and when the weather is at all inclined to be dry, such 'slips' tend to die and it is safer to propagate by seeds.

Calopogonium produces numerous shallow roots with numbers of nodules on them, but its root system is rather shallow on the whole. For this reason it is not well suited to drier districts where the rainfall is under 35 inches, and it does best in the Closed Forest country where the rainfall is 50 inches or more. In such districts it keeps green throughout the dry season as well, and forms an almost ideal cover crop, and is excellent when grown in young plantations of oil plams, Para rubber, and coconuts, as it smothers out the weeds, prevents soil wash, and adds plant food to the soil.

The fruits and seeds are small and the latter are rather difficult to gather, but in wet climates the plant readily reproduces itself by self-sown seed, so that it does not need special replanting, but will continue year after year on the same piece of land.

Calopogonium is an excellent crop in the forest country to prevent soil wash on slopes, as the mass of intertwining stems rooting at the nodes, the thick mass of green foliage, and the mat of dead leaves under them, all help to prevent soil wash and continue to add a great amount of humus to the soil.

In drier districts the plant is harder to establish and tends to die out in the dry season. Also, although it does add a good deal of humus in the form of dead leaves, its root system is shallow and therefore it does not enrich the lower layers of the soil or improve the tilth and depth of the soil to the same extent as deeper rooted crops such as the *Crotalarias*.

4. LABLAB BEAN [Dolichos Lablab]

This is a strong-growing creeper, said to be a native of the East Indies and common on the Egyptian coast of Africa. The leaves are compound, consisting of three large leaflets. The flowers are produced in clusters on stalks borne in the axils of the leaves. They are violet in colour and are followed by slightly curved pods, 2 inches long and 1 inch broad, and slightly upturned at the tip. The seed is characteristic in appearance,

generally being flattened, black in colour, and with a conspicuous white hilum around one-third of the circumference.

There are other varieties with mottled seeds, and one variety has white flowers and white seeds. This latter variety is not so common in West Africa as the black- and mottled-seeded varieties.

There is also a bushy variety which does not climb, but this is grown chiefly in America, and it is the climbing variety that is most commonly seen in West Africa.

The Lablab bean thrives in most soils in West Africa, and in most climates provided that they are not too wet. It quickly produces dense masses of foliage and, if planted between other crops, such as corn or more permanent crops, the stems quickly climb over and smother them, so that it is better to grow this crop on a piece of land by itself. Its vigorous growth helps it to smother out most weeds with comparative ease. It remains green even in the dry season and is an excellent cover crop.

The young green pods can be eaten whole like French beans, and the ripe seeds can also be cooked and eaten. If the ripe fruits are allowed to remain too long on the plant they are often attacked by grubs, which bore into and destroy the seeds.

This plant produces masses of leaves which drop on to the soil and enrich it, but if it is dug in while in full flower it benefits the soil still more by adding a large amount of humus in a form in which it will quickly decay. Even if it is not dug into the land it forms a good cover in the dry weather and produces a new growth of leaves in the following rainy season.

Although the foliage can be used for feeding live stock, it is not of such good quality as that of pigeon peas or *Crotalaria*.

Besides the above ground-cover crops generally grown as a green manure only, some of the leguminous plants in the chapter on 'Edible Legumes' can also be mentioned here.

5. THE COW PEA [VIGNA UNGUICULATA]

The cow pea forms an excellent green manure and 'catch crop', especially if planted during the small rains, as it quickly produces a mass of foliage which is over in about three months, but if dug in before the leaves fall, it forms an excellent soil improver, especially between two main crops grown in two main rainy seasons. The cow pea, unfortunately, cannot endure drought and is therefore killed off in the dry season. There are

several varieties of cow peas, with various coloured seeds. The varieties which are the most leafy are suitable as green manures.

6. MISCELLANEOUS ANNUALS

The 'Jerusalem' pea (? *Phaseolus trinervis*) which forms an even denser mass of foliage than the cow pea, lasts longer, and can withstand much more drought. The 'Jerusalem' pea is an excellent ground cover and green manure and is a useful catch crop in the small rains. It does well in regions of moderate or light rainfall. The climbing variety of Lima or butter bean (*Phaseolus lunatus*) can also be used as a green manure, and produces a mass of foliage, but it is generally grown for its edible beans. Even if the beans are picked and the whole plant is then dug into the soil it is a useful green manure crop.

Both the climbing and dwarf varieties of the sword bean (*Canavalia ensiformis*) are suitable as green manures and are often seen in West African school gardens. The climbing variety produces more foliage than the dwarf variety, and both enrich the soil considerably when dug in. They are not so valuable as cover crops, as they do not endure the dry season as well as *Dolichos Lablab*, *Centrosema*, and the erect cover crops.

The fuller details and uses of the sword bean are given in the chapter on 'Edible Legumes'.

Two or more species of *Centrosema* are sometimes seen on Agricultural Stations as green manures. There are generally *Centrosema Plumieri* and *Centrosema pubescens*, both of which are excellent ground covers, producing a thick carpet of stems and foliage on the surface of the soil. They do not spread as rapidly as *Dolichos* or 'Mucuna' and are therefore suggested as an excellent cover crop between more permanent crops, which they do not tend to smother out. In their habit of growth they somewhat resemble *Calopogonium*, with the additional advantage that they remain much greener during the dry season. Their seeds are not edible.

Fuller details of *Centrosema* can be obtained from Government Experimental Stations or more advanced books on tropical agriculture.

Other suitable green manure crops, such as the Sarawak bean (*Vigna oligosperma*) and others being introduced into West Africa from time to time are still too much in the experimental stage to be dealt with further here.

PERENNIALS

1. *CROTOLARIAS*

The *Crotalarias* are quite different in their habit of growth from the previously mentioned leguminous plants. They are erect in growth and from 3 to 7 feet in height, the stems being somewhat woody at the base.

Crotalarias are very similar to each other in general appearance. Some have simple leaves and others compound leaves consisting of three leaflets. The flowers are usually yellow and generally have thin red stripes on the petals; all have short inflated pods inside which the small seeds rattle when the fruits are ripe (the name is derived from a Greek word *krotalon*, meaning 'a rattle').

The *Crotalarias* have a distinct advantage in that they can often be grown on poor soils, which they help to improve considerably. Most of them will do well in quite dry climates, and all possess deep tap-roots, a *Crotalaria* plant 3 feet high being found to have a tap-root at least 3 feet long. Their deep root system helps them to thrive even in poor soils and dry climates, and sometimes to endure into the dry season. The depth to which the roots penetrate is also a very great advantage to the farmer as they help to open up the subsoil and allow water and air to penetrate more deeply into the soil. They also add plant food to the lower layers of the soil, both by the nitrogen collecting nodules on their roots and by the amount of humus the roots and rootlets add to the soil when they die. Although *Crotalarias* do not appear to produce such a mass of foliage as other green manures, such as *Calopogonium* and *Mucuna*, yet the far greater root development of *Crotalarias* enrich the soil more than would appear from a superficial observation, and it has actually been proved by experiment that *Crotalarias* enrich poor soils more than the other more leafy green manures mentioned.

The *Crotalarias*, nevertheless, produce quite a mass of foliage, and, if planted in rows 3 feet apart and carefully looked after and weeded in their earlier stages, they quickly form a dense growth and cast thick shade between the rows, so that few weeds can survive. After two and a half or three months they produce great numbers of seeds and continue to produce crops of seeds for weeks and even months afterwards.

Crotalaria striata, a species with three leaflets having blunt, rounded tips, produces one of the best and thickest of erect

covers and reaches a height of 6 to 7 feet, with numerous succulent young stems. It also drops a constant supply of dead leaves between the rows, which, together with its deep root-system, helps to enrich the soil. It is an excellent crop for smothering out weeds.

If the plant is to be dug into the soil, it should not be allowed to stay until it becomes too woody. The stems contain a fibre which is inferior to that of Sunn hemp (*Crotalaria juncea*).

Sunn hemp (*Crotalaria juncea*) is quite different in appearance from *C. striata* and is much less bushy in growth. The stems are slender and covered with short silky hairs. The leaves are simple, narrow, and from 1½ to 3 inches long. The flowers are yellow, produced in a spike at the ends of the branches and the pods are short and inflated.

Sunn hemp does well in dry climates, and even in poor soils. The seeds germinate quickly, sometimes appearing within twenty-four hours of planting. They should be sown 3 to 4 inches apart, and once they become established they are little trouble. They generally grow from 4 to 8 feet in height and mature in three to four months, so that two and even three crops can be obtained in West Africa in the year.

In India, where the plants are grown specially as a green manure, they are uprooted after two or two and a half months' growth and ploughed in.

Sunn hemp is used in India and the East as a fibre plant and its stems contain fibre which is practically the same quality as true hemp (*Cannabis sativa*) and is used for making ropes, twine, sacking, paper pulp, and fishing-nets. The plants are best cut when in flower if needed for fibre, although a still coarser fibre can be obtained from the stems if the plants are cut after they have finished seeding.

The foliage and seeds of Sunn hemp are used in India for feeding cattle.

Sunn hemp forms an excellent cover crop and soil improver, even in poor, dry soils, and if sown thickly it helps to smother out weeds.

There are other species of *Crotalaria* that have been grown in West Africa as cover crops, and the seeds of the different species can generally be obtained from Agricultural Departments.

There are also several species of wild *Crotalaria* in West Africa which would form good cover crops and green manures, if trouble was taken to collect and grow the seeds.

2. JAVA or NATAL INDIGO [INDIGOFERA ARRECTA]

This is an indigenous plant which has been tried out successfully as a cover crop at Kumasi Agricultural Station. It is an erect shrub of bushy growth, growing to a height of 4 feet or more, with bluish-green compound leaves, small red flowers, and numerous cylindrical dark-brown pods, about 1 inch in length, produced in masses along the stems at some distance from the tips.

In Northern Ashanti the Africans are said to remove the leaves from time to time to make a blue dye (indigo) and it is used in Ilorin, Nigeria, for the same purpose.

Indigofera does best in rich, well-drained, loamy soils with an average rainfall. Although a native of the more open districts, it can be grown satisfactorily in Closed Forest districts as a green manure. The seeds have rather a thick seed-coat or testa so that they sometimes do not germinate very well; therefore they should be sown thickly and the plants can be thinned out later on to a distance of 6 inches apart.

When the leaves are not removed for the making of indigo, or pulled off and spread on the ground as a leaf-mulch, the plant will survive over one season and tends to become a perennial.

It has a deep root-system with a plentiful supply of nodules and is therefore a valuable soil improver. Its dense growth of leaves helps it to be a useful crop for smothering out weeds, and the numerous leaves shed by it also enrich the soil.

When coppiced, or cut down almost to the ground, it recovers well and soon produces fresh masses of foliage, recovering better in this way even than pigeon peas. It gives a denser shade than pigeon peas, it lasts longer, and endures the dry weather better.

Besides being an excellent crop for improving the soil and for killing out weeds on poor soils, *Indigofera arrecta* has been suggested for intercropping in young cacao and oil palm farms, to provide shade and protection from wind for the young plants, and also to help to smother out weeds and to improve the soil.

There are several other species of *Indigofera* which occur wild in West Africa and which could well be tried out for green manures or cover crops, if trouble was taken to collect their seeds in the dry season and trial plots were grown in the following rains.

3. *TEPHROSIA* SPECIES

These are erect-growing bushy plants, with compound leaves, generally covered with silky hairs, white or purple flowers, and flat pods also covered with silky hairs.

They do best in rich, loamy, well-drained soils, and form a dense mass of foliage which gives so much shade that few weeds

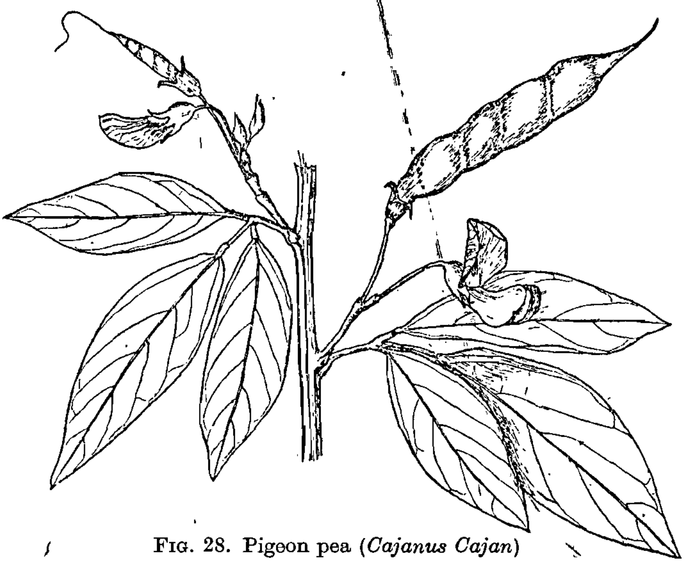

Fig. 28. Pigeon pea (*Cajanus Cajan*)

can flourish beneath them. They have deep root-systems and are excellent soil improvers and last well into the dry season. They coppice well and have the advantage of lasting for two or more seasons on the same piece of land without replanting.

They are recommended for interplanting in young plantations of cacao or oil palms.

Tephrosia candida, with large white flowers, is the species most generally grown on Experimental Stations, but there are several African species, such as *Tephrosia elegans*, *Tephrosia purpurea* and *Tephrosia Vogelii*—the fish poison plant—which could well be introduced into cultivation as perennial cover crops. Some species of *Sesbania* could also be grown as erect cover crops.

4. PIGEON PEA [CAJANUS CAJAN]

The pigeon pea (Fig. 28), already dealt with in the chapter on 'Edible Legumes', is also of considerable value as an erect cover crop. It possesses a deep root-system which opens up and enriches the subsoil to a considerable depth. If planted in rows 3 feet apart it quickly produces a dense shade in which weeds cannot thrive, and as the dry season approaches it drops masses of leaves which form a carpet or leaf-mulch 1 inch or more in thickness. The branches can be lopped off and spread on the surface of the ground as a leaf-mulch, and the plant will produce new growth in the following season. It does not thrive well after more than two or three seasons, two years being generally long enough for its growth. It is suggested as a two years' cover crop for improving soil impoverished by an exhausting crop such as cassava.

CHAPTER XXIX

MISCELLANEOUS CROPS: SUGAR-CANE. TOBACCO. GINGER. BENNISEED

SUGAR-CANE [SACCHARUM OFFICINARUM]

THE sugar-cane is found in all parts of the tropics and is cultivated on a commercial scale for sugar extraction mainly in the West Indies, Mauritius, Natal, Queensland, Guiana, Fiji, Hawaii, British India, and in Central and South America. In West Africa it is grown mainly for home use, particularly for chewing, and is not exported.

The sugar-cane is a perennial plant belonging to the grass family. It has fibrous roots, thick strong-jointed stems in which the sugar is stored, and a number of large leaves. It produces flowers which grow in a feathery cluster at the top of the stems. These flowers, however, seldom produce fertile seeds in West Africa, unless pollination is assisted.

In those parts of the world where the sugar-cane is an important crop, considerable work has been done with breeding and development by growing new varieties from seeds, and by careful selection and breeding until varieties producing much larger quantities of sugar have been produced. Consequently, there are a great number of varieties of sugar-cane, some of the most prolific varieties being known only by the catalogue entry number, e.g. B 211.

The once-famous West Indian plantation sugar industry suffered from the abolition of slavery, the more antiquated methods of handling the canes, the competition of beet-sugar grown in Europe, and the breeding of more prolific varieties elsewhere. The sugar-cane is now one of the most specialized of tropical crops, and only where there are enormous central factories with the most up-to-date methods of handling the canes, is the sugar-planter able to hold his own in the modern world. The sugar-cane is probably the best example of a highly technical and capitalized tropical crop, and for that reason it is unlikely that West Africa, with its peasant methods of agriculture, will ever attempt to produce cane-sugar for export. Nevertheless, it is an important crop and much more use should be made of the sugar-cane locally in West Africa than is done at present.

The common types of sugar-cane found in West African farms are much inferior to the modern commercial types, being generally more woody and containing a correspondingly lower amount of juice. Nevertheless, the Agricultural Departments have introduced improved types from the West Indies and elsewhere, and the descendants of these introduced types can be found in West Africa to-day.

The sugar-cane is quite an easy crop to grow. Although it will grow in most soils it does best in a deep, rich, clay loam, preferably in river-valleys. The soil should be well drained and the crop will be improved by the addition of lime in localities where this is deficient. The sugar-cane does not thrive so well in hilly districts. It likes a humid climate, but will grow well in dry districts if it is irrigated. It can be grown quite near the sea provided that the soil and rainfall are suitable, and it does not seem to suffer from moderate sea breezes in the way that most crops do.

The farmer always propagates the sugar-cane by cuttings, whereas the plant-breeder uses the seeds to produce new varieties. The cuttings are generally taken towards the top of the canes, after the leaves have been removed. Only the best canes should be selected for propagation as otherwise the crop will gradually deteriorate. Each cutting, which is only 6 to 8 inches in length, contains three or four joints, each joint containing a bud or 'eye'. These cuttings, which are known in the West Indies as 'plants', are then planted in a sloping position. The land should be thoroughly cleared of weeds before planting takes place. Holes are dug with a hoe, and if the soil in the bottom of the hole is at all hard it should be loosened thoroughly before the 'plants' are put in, so that their roots can grow down into the soil easily. The distance of planting depends upon the type of soil, being farther apart on rich soils and closer together on poor soils. The average distance in the West Indies is 5 feet apart both ways, while on good land the plants may be 6 feet apart and the rows 7 feet apart. In West Africa the planting distances are usually much less than this, and larger crops would be produced if the land was more thoroughly prepared beforehand, and if the distances between the plants were to be increased.

Some planters recommend that the cuttings should stand for an hour or so in slaked lime and water, as this helps to destroy any insects or diseases present.

One or two 'plants' are placed in each hole, with only about an inch of the cutting remaining above ground. If the planting is done in favourable weather the 'plants' take root in about a fortnight, and the first growth or mother-shoot appears above ground. The main or mother-shoot should be cut out later so as to help the plant to throw all its strength into the other shoots.

Where some of the 'plants' fail to grow, it is best to have a small nursery of selected rooted cuttings ready, and to plant them into the vacancies.

During its growth the sugar-cane plantation should be kept thoroughly cultivated and free from weeds. Some plants throw out flowering shoots which are of a delicate pinkish-purple shade, feathery in appearance, and pyramidal in shape. As we have seen, sugar-canes in West Africa seldom produce fertile seeds. During the process of flowering, the canes are not so rich in sugar owing to the energy required by the plant to produce flowers. After flowering the plant quickly recovers and once more stores sugar in its stem.

As the cane grows the lower leaves die, but still remain attached to the stem. They should not be touched in the dry season, but when the weather becomes wetter it is best to pull them off and apply them as a 'leaf mulch' to the soil around the plants. This process, known by cane-planters as 'trashing', helps the air to circulate more freely amongst the canes in the damp season, and also adds plant-food to the soil.

In dry districts the canes themselves are sometimes troubled with attacks from termites or white ants which bore into the stem. They are particularly troublesome in the dry season and in dry districts.

In West Africa the sugar-cane is seldom grown with as much care as is recommended here. The canes are usually grown on rich, low-lying soils in valleys. In Hausa districts they are grown on small strips of land along the edges of rice-fields, while in the drier northern regions the crop is sometimes irrigated. In Kano district a reddish-stemmed variety is grown, but a yellow-stemmed variety appears to be common in most districts.

After twelve or fourteen months the canes are ready for harvesting. A ripe cane can generally be distinguished by the smooth and brittle appearance of the skin, by its greater weight, and by the dry appearance of its interior. When an unripe cane is broken across, however, it usually breaks cleanly at a node, and the interior is soft and moist, owing to the unprepared

sugar present, whereas a ripe cane breaks in a more jagged fashion as it is more fibrous.

The canes are cut near the ground, as this helps the new crop to start better, and also, the nearer the bottom of the stem one goes, the greater the amount of sugar present. The leaves are cut off and the ripe canes, either whole or cut into pieces, are carried to the markets where they are sold for chewing purposes only.

In Northern Nigeria the leaves of the sugar-cane and the green stalks are used as cattle fodder.

Sugar-cane is generally allowed to remain on a piece of land for two or more seasons. After the first crop of cane has been cut, a new growth of stems takes place, forming what is known as the 'rattoon' crop. This is cut in due course in the same way as the first crop, and a third crop then appears which is known as the 'second rattoon', and so on. Generally after a first or second rattoon crop the soil becomes so impoverished that it is necessary either to manure it liberally or to dig out the crop and fallow the land or plant some other type of crop.

There is no need to enter into details as to the complicated methods of preparing sugar from the canes by machinery, as that is fully described in more advanced books, and is not practicable at present in West Africa. It is of interest and value to West Africans, however, to know that sugar *can* be made from the sugar-cane, and there are various home-made methods of crushing the cane and extracting the juice.

Simple cane-crushing mills, worked by manual labour, by one animal, or by a motor can be bought for about £12 or £15. Simpler home-made devices can also be used. In East Africa cane syrup is sometimes crushed out of the canes by an African-made crusher. The chief disadvantage is that it is not possible to extract all the cane-juice by hand methods.

The crude or fresh syrup is then boiled in open pans, as it quickly ferments and must be heated or 'clarified' in this way. The remains of the crushed cane, known as 'cane trash' or 'megass', serve as fuel if wood is not obtainable.

The vegetable acids in the juice are neutralized with unslaked lime and the impurities, which rise as scum, can be easily removed. As the juice becomes purer and more concentrated, a thick syrup is left. The thick brown liquid on top is known commercially as 'molasses' and is used as a valuable cattle food in Europe and America. It is also an excellent food for human

beings and is the source of various treacles and of the well-known 'golden syrup'. The crystals which remain at the bottom represent the cane-sugar. They are brown in colour and sticky, even when dried. This sticky brown sugar, which is known in commerce as 'Demerara sugar', is actually sweeter than the purified white cane-sugar and is of higher food value; it contains more of the ash and proteins which are present in the original juice. The well-known white cane-sugar represents the final stage in the purification of cane-sugar, and although it is not possible to make pure white sugar without elaborate machinery in West Africa, the brown treacle or molasses and the rich brown sugar can be made quite easily by the method described above. In 1918 the Church Missionary Society in Zaria, Northern Nigeria, actually produced and sold 'soft molasses sugar', and 'crystalline Demerara type' from locally grown sugar-cane.

TOBACCO [Nicotiana rustica and Nicotiana tabacum]

There are two kinds of tobacco plants commonly grown in West Africa. The yellow-flowered or Turkish tobacco (*Nicotiana rustica*) is grown in French Guinea, the northern regions of Sierra Leone, the Sudan, and in East Africa. It is a branched herb up to 4 feet high and has greenish-yellow flowers. The ordinary tobacco plant (*Nicotiana tabacum*) (Fig. 29) is grown by most West African tribes and is distinguished from Turkish tobacco by its taller growth and by its longer tubular flowers which are generally white or pinkish, or occasionally pale yellow.

In West Africa the tobacco plant is generally grown in compounds and enclosures near villages.

Some tribes, however, take more care with it and grow it as a special field-crop. Tobacco needs more care than most crops, however, especially in the early stages, as the seeds are so tiny (more than 300,000 to the ounce). For this reason they are generally sown in special nursery beds at first, and are carefully watered, shaded, and tended until they are large enough to transplant. Tobacco grows best in a rich loamy soil and responds well to manuring.

In Sierra Leone it is grown as a field crop in the more open country in the northern plateau area, and both types of tobacco are cultivated. According to Glanville the main details of its cultivation are as follows:

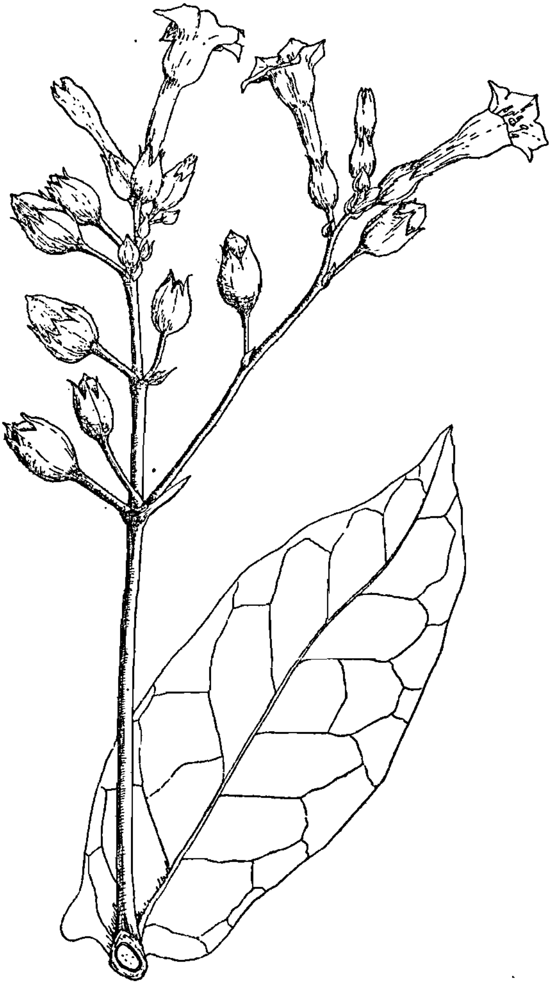

FIG. 29. Tobacco (*Nicotiana tabacum*)

Two crops are grown yearly, the main crop being grown at the end of the rainy season, and the smaller crop under irrigation in the dry season.

For the main crop the seed is sown thickly on a seed-bed in August, and six weeks later it is transplanted to flat-topped mounds about 12 inches high. The best crops are raised in well-drained soils, and the crop is harvested in November. It is generally grown after some other crop, such as fundi, but sometimes the bush is specially cleared for it.

The dry season crop is sown near streams and in valleys, and often after swamp rice. The seed is sown in November, transplanted in late December or late January into slightly concave beds about 3 feet high and 3 to 4 feet in diameter. These beds are carefully prepared and the soil is manured with a compost of burnt cow-dung and rice husks. The growing crop is watered by hand every evening by women.

In Nigeria, also, great care is taken in some parts with the cultivation of tobacco, the Yorubas and Nupes often specially manuring their crops of onions and tobacco, wood ashes being the special manure generally used for the tobacco crop. In parts of the Northern Territories of the Gold Coast care is also taken in manuring the soil for the tobacco crop. There it is one of the few crops not grown under mixed cultivation.

In Northern Nigeria tobacco is often grown as an irrigated crop in river valleys, and the crop is also manured with ashes, house-sweepings, and even cow-dung.

The Hausas used the flowers of the tobacco plant to rub on the teeth to stain them red while chewing certain kinds of cola nuts.

There are various simple African methods of curing tobacco.

In Sierra Leone the leaves are not fermented but are dried in the sun for about three days only and then made into round bundles. The dried leaves are shrivelled and dark-greenish brown, and about 50 or 60 of the larger leaves are used for making these round bundles. The leaves are tied together by their stalks and a handful of smaller leaves are put into the centre of the bundle which is then tied up by a piece of fibre wrapped spirally round it.

In Yoruba country the curing of the leaves seems to be done completely in the sun and the leaves have a somewhat light colour and a mild flavour. Both old and immature leaves are picked and dried together, so that the final product is not graded in any way, but is of mixed quality and inferior to imported tobacco leaves. The local demands for African tobacco are so great in West Africa that no export trade in tobacco has yet grown up. For export purposes improved American and other

types would need to be grown, and greater care taken with their cultivation, shading, pruning, picking, drying, curing, and grading. As all the details of the proper cultivation of tobacco as a field crop are given in more advanced agricultural books, only a few details of the West African methods of growing and curing the crop are dealt with here.

The dried tobacco leaves are rolled into balls or twisted into ropes or plaits, or made into flat bundles and sold locally. Such home-made tobacco is generally smoked, or sometimes chewed or made into snuff. Snuff is much used in West Africa and is prepared by the leaves being thoroughly dried and then pounded up into a powder, or ground up on stones. Dried plantain skins, which have been burnt to ashes, are generally mixed with the powdered tobacco leaves or dried and powdered midribs of the leaves, in the making of home-made snuff. Sometimes crude sodium carbonate, a salt sold in most markets, is added to the snuff.

In Europe and America a poison called nicotine is extracted from the refuse of tobacco factories, such refuse being mainly the midribs of the leaves. This nicotine is used in the manufacture of certain sheep dips and also in the making of such insecticides as nicotine sulphate and other compounds of nicotine. (For fuller details of insecticides see chapter on 'Insect Pests'.)

GINGER [ZINGIBER OFFICINALE]

The ginger plant is a native of tropical Asia and is grown in many parts of the tropics, the main countries from which ginger is exported being China, Japan, Jamaica, and West Africa (Sierra Leone). It grows from 1 to 3 feet in height and consists of an enlarged underground stem or rhizome which is lobed in shape, and erect stems with narrow, parallel-veined leaves, about 6 inches in length, on each side. The flowers are produced on a flower-stalk, which arises separately from the rhizome, and which is 6 to 12 inches high. They are yellowish-white in colour. The fruit is rarely seen.

It is from the rhizome that the ginger of commerce is prepared. The rhizome is also the portion of the plant used for propagation. When mature it can be broken into several pieces and planted in holes 1 foot apart and 2 to 3 inches deep. (Plate XXXI *a*.)

Ginger will grow in many parts of West Africa and requires a moderate or rather heavy rainfall. If grown in regions of light

rainfall (30–40 inches) it does better when it can be irrigated. It is not worth while attempting to grow ginger where the rainfall is less than 30 inches. It does best in Closed Forest country and in rather shady positions, where the rainfall is fairly well distributed, and it will grow in districts up to 4,000 feet in altitude. It yields best in rich, well-drained soils, while in Sierra Leone much of the ginger crop is grown on rather gravelly soils from which the 'bush' has recently been cleared, so that it is quite rich in humus.

In the Mende districts of Sierra Leone, where ginger is grown for export purposes, the weeds are dug up and the ground thoroughly loosened with a hoe, the type of hoe used being narrow, with a blunt point. The shape of this hoe also enables the farmer to clear away the weeds later on from between the closely growing ginger stems. (Plate XXXI *b*.)

The ginger plant takes nine or ten months to reach maturity, most of its growth taking place during the rainy season. During its period of growth it requires little attention beyond weeding and cultivation of the soil. If the weather or the climate is too dry it responds to irrigation, and is also a crop which benefits considerably from liberal manuring.

When the leaves begin to turn yellow the crop is mature and the rhizomes are then generally harvested gradually.

The cleaning and preparation of ginger requires a considerable amount of labour. After digging the rhizomes, as much of the soil as possible is shaken off, the remainder being washed off, and all the roots attached to the rhizomes are removed. Great care should be taken not to bruise or injure the rhizomes when harvesting them.

If any of the ginger rhizomes are left in the soil at the time of harvest, they produce what is known as 'rattoon ginger' which is of inferior quality. Ginger should only be allowed to occupy the land for one season (nine to ten months), after which it should be removed entirely and some other crop grown.

After the roots have been removed the rhizomes are generally washed, scraped to remove the outside layer, and dried in the sun for a week or so. Such ginger is known as peeled or scraped ginger. In the Eastern tropics the rhizomes are sometimes scalded in boiling water before the skin is removed with a narrow-bladed knife.

The peeled ginger is sometimes bleached, either with chloride of lime, or with lime and water. The rhizomes may be merely

washed and then dried to remove as much of their water as possible, or they may be boiled for a short time as well. Such ginger is then sold as unpeeled or unscraped ginger.

An average yield in the Eastern tropics is 1,500 lb. per acre of cured ginger.

Ginger is used commercially as a spice, particularly in confectionery such as ginger cakes, and in mineral water manufacture in the making of ginger beer and ginger ale. For these purposes the poorer qualities of ginger as exported from West Africa are suitable.

The best ginger, which comes from the delta of the Canton River in China, is not so coarse and is made from the tender growing-points of the rhizomes. Hence it is not so fibrous as the West African ginger which is prepared from mature rhizomes. These tender portions are then peeled and preserved in sugar syrup. A kind of ginger known as 'Chinese Green Ginger' is specially grown for this purpose.

Preserved ginger, however, can quite well be made at home in West Africa if the more tender parts of the rhizomes or young rhizomes are chosen. They are put into freshly boiled water every night and morning for a fortnight. The object of this is to allow the rhizomes to become thoroughly soaked, the cooled water being thrown away every time before they are put into the next lot of boiling water. Finally the outside skin of the rhizomes is removed with a sharp knife or scraper, and the peeled ginger is then boiled in water until quite soft, after which it is chopped up, or cut into any sizes desired. A sugar syrup is then prepared in the proportion of 1 lb. of loaf sugar to half a pint of water, the peeled and sliced ginger is added to it, and it is boiled until the syrup becomes a clear brown colour, after which the preserved ginger and syrup is ready for use.

BENNISEED, SESAME, GINGELLY

[SESAMUM INDICUM and SESAMUM RADIATUM]

There are two kinds or species of the *Sesamum* plant and it is not always easy to distinguish between them. *Sesamum indicum* often has its lower leaves consisting of three leaflets, flowers about 1 inch in length, white or pinkish or spotted, and smooth seeds, whereas *Sesamum radiatum* always has simple leaves which are often toothed, its flowers are 1 to 1½ inches in length and reddish-purple in colour, and its seeds are wrinkled.

The gingelly plant (*S. indicum*) (Fig. 30) is believed to be

FIG. 30. Benniseed (*Sesamum*)

a native of tropical Africa, even though it is grown so exte sively in India. It is grown in various parts of the tropics a sub-tropics, including many parts of West Africa. It is annual plant and thrives best in the drier regions away frc the closed forest. It is grown in the Northern Territories the Gold Coast, where the Dagomba farmers plant it in Jı and harvest it from December to February. It is planted ridges 4 feet apart in holes 18 inches apart along the sides the ridges. It is one of the few crops grown by itself and r under mixed cultivation. The leaves are picked and used : soup. When the crop is ripe, which is when the pods are pa yellow, it is pulled up by the roots and left in the sun until t pods are completely dry. The seeds are then shaken out of t pods on to the hard ground, collected, and stored.

Some varieties have whitish seeds and others have bla seeds. The white-, pink-, or red-seeded kinds are said to better for use as human food, whereas the black-seeded kind used more for commercial purposes.

In Northern Nigeria benniseed is grown alone and not mix with other crops, and only one crop per year is obtaine although there is no reason why two crops per year should n be obtained, as in India, if irrigation was used.

The plant thrives in a sandy loam or loamy soil and nee plenty of moisture during its earlier stages, for about tv months, after which it does best with dry weather during time of flowering and setting seed.

The seeds are rich in oil known as sesame or gingelly oil, whi is used as food. In Northern Nigeria the oil obtained from t seeds is clear yellow, has little or no smell, and keeps long wit out turning rancid, so that it is much liked for food purpose The Hausas also use the seeds in the making of a kind of pc ridge. The Dagomba tribe in the Gold Coast use them in sou

In Northern Nigeria there is an export trade in the see which are known as benniseed, and, as the crop is comparative easy to grow, it could be cultivated and exported from We Africa much more than it is.

The oil is a valuable substitute for the more expensive oli oil, and is used in making butter substitutes and in soa making. The residue or 'cake' remaining after the oil has be pressed out of the seeds is used in Europe as an importa cattle food, or as a manure.

Sesamum radiatum can be and is sometimes grown and us

in the same way, but it is more often found growing wild. Both plants can also be grown and used as green manure crops.

Another closely related plant which is prostrate in habit and grows only from ½ foot to 2 feet in height and with smaller flowers and fruits is also sometimes seen. Its botanical name is *Ceratotheca sesamoides*, and in Hausa it is known as *Karkashi* or *Kalkashi*, whereas in the Northern Territories of the Gold Coast it is known as *Bungu* and is grown as a special field crop. It is generally sown alone or sometimes interplanted with corn and yams, when it is sown in March to May and harvested four to five months later. If sown alone, it is planted in July or August and harvested in March.

The leaves are used in soup, and the seeds are small, brown, or black in colour, and are eaten in parts of tropical Africa, such as in Uganda.

In the Northern Territories of the Gold Coast the seeds are shelled, roasted, and ground to a paste between stones. The paste is then added to the soup as a flavouring.

Both *Sesamum* and *Ceratotheca* are often found growing wild.

CHAPTER XXX

PROPAGATION OF PLANTS. BUDDING AND GRAFTING

THE PROPAGATION OF PLANTS

PLANTS are propagated either by seeds, or by stems, roots, or leaves. Propagation by seeds is generally known as sexual reproduction, because the male and female parts of the flower, the stamens and pistil respectively, have both played their part in the production of the seed. Propagation of plants by portions other than the seed is generally known as vegetative reproduction, because the vegetative portions of the plant have been used.

SEXUAL REPRODUCTION OF PLANTS

The propagation of plants by seeds is used in most farm crops. Seeds contain within themselves not only the ability to produce plants resembling their parents, but also characteristics like their ancestors two, three, or more generations back. For example, corn seed from a corn cob on which, say, one-third of the seeds were yellow, one-third white, and one-third red would not necessarily produce equal numbers of plants bearing red, yellow, and white seeds. The numbers would probably vary considerably, owing to the mixed ancestry, and also, of course, to the effect of further cross-pollination. Similarly, all the seeds sown from a very large tomato fruit would not all grow into plants producing tomatoes of the same large size. In all probability, some would bear large fruits, others fruits of medium size, and others small fruits. Therefore plants sown from seed show great variability and also exhibit the different characteristics of their ancestors.

Every farmer has noticed the variability in individual members of any one crop sown from seed, even where conditions of planting and of water-supply and soil conditions are practically the same. A good farmer, in taking seed from any one crop for growing in the next season, would select seeds from his best plants only. Any one growing orange trees from seed, for example, would naturally plant seeds from a sweet fruit and not from a sour fruit, or better still, from a tree which is *always* known to yield a *heavy* crop and a *large percentage* of sweet fruits. Even then there is no guarantee that every seedling tree

grown in this way will bear heavy crops of sweet oranges. Some will probably not do so, and care should be taken in future not to collect seed from these inferior trees. If only the best trees were selected and seeds sown from them only, in every generation the percentage of trees bearing heavy crops of good fruits would be increased. The same applies to any crop grown from seed, and whether this simple principle is carried out by a farmer or by a trained plant breeder, it is called 'selection'. Selection can be carried out for the development of any characteristic required in any particular plant. For example, crops may be bred and selected in this way to produce future crops with such characteristics as height, yield, quality of fruit or seed, early or late maturing seeds, luxuriance of leaf or flowers, or numerous other characteristics required by farmers or gardeners. By this method of selection the original food plants were brought as wild plants by primitive man and grown on his farms, during that time in his civilization when he ceased to be a hunter, feeding upon wild fruits and roots, and started to clear and plant farms. By continued 'selection' of this elementary kind, the varieties of our food plants arose. If any one tries to collect together all the known varieties of crops like cassava, yams, or beans in his own district, he will be amazed at the number of them.

Trained plant-breeders have worked for years on some of the commercial crops such as cotton, corn, sugar-cane, and others, breeding and selecting the best varieties for various purposes. They have even gone further and have started cross-pollinating some varieties with others, thereby producing cross-breeds bearing the characteristics that they require. In these two ways, by selection and cross-breeding, they have produced numerous varieties, and any one attempting to do the same can produce new varieties of his own. In crops such as cotton, corn, and others, the recognized varieties number hundreds, and every year new varieties are being produced. This does not include the number of varieties which have been rejected as unsuitable by plant breeders, so that in consequence crops such as cotton and others have so many varieties that it is often difficult to distinguish them from each other.

With crops like cassava or sugar-cane which are not normally propagated by seed, new varieties can be developed by planting any seeds which appear and developing new varieties by selection and cross-breeding. As all this work is so technical

nowadays it is only mentioned here and can be studied further in other text-books. Plant breeding is only beginning in West Africa, Ishan cotton being one of its most striking successes, but much can yet be done with other food and commercial crops, as well as with the selection and breeding of beautiful wild West African plants which could be developed into decorative garden plants.

VEGETATIVE PROPAGATION

This method of propagating plants has the advantage of reproducing the characters of one parent only, for if a cutting, or other vegetative portion is used, it is still a part of the original plant, whereas when seeds are used, the special characters of the plant are not always perpetuated, as we have seen. Therefore, by vegetative propagation the same variety can be reproduced indefinitely and without change, the only way of producing a change or a new variety being to grow it from seed.

In the tropics, and the damp parts of the tropics particularly, vegetative propagation seems to be much more possible and more widely used than in temperate regions.

There are numerous ways in which plants can be propagated vegetatively. Some of these are by (1) cuttings; (2) underground stems; (3) suckers; (4) layering; (5) bulbils.

1. Cuttings

Portions of plants when cut into sections and planted can produce new plants. Such portions, or 'cuttings' as they are called, may be either (A) stem cuttings, (B) root cuttings, or (C) leaf cuttings.

A. *Stem Cuttings.* Many plants are propagated by portions of their stems being cut and inserted in damp soil or damp sand. Some of the trees used for fencing African compounds grow so easily that when large branches of them are stuck into the ground they take root and grow. Not all plants can be propagated in this way, as some grow readily from cuttings, others only after great care, and some not at all. There are two generally recognized types of stem cuttings which are known as hardwood and soft-wood cuttings.

Hardwood cuttings, as their name implies, are cuttings made from the hard wood of perennial plants, especially shrubs and trees. Many garden shrubs such as *Crotons, Hibiscus, Panax,* and others are propagated in this way. As these plants are per-

ennial, their stems contain a certain amount of stored food, especially at particular times of the year such as in the dry season. Cassava stems, for example, when cut into pieces and planted will grow, producing roots and stems and leaves and forming new plants. This they are able to do because the stems contain a certain amount of stored food, and under suitable conditions the buds on the stems are able to spring into growth, those below the soil being able to produce roots, and those above ground, stems and leaves. Care should of course be taken to see that the stems are planted the right way up. Citrus fruit trees can even be grown from cuttings if handled carefully, and papaws can also be propagated by cuttings 3 to 6 feet long. Similarly, stems of sugar-cane, in which quantities of food is stored in the form of cane-sugar, can produce new plants when they are cut into pieces and planted, the new roots and shoots appearing at the joints or nodes.

Soft-wood cuttings are cuttings of soft green stems which will grow when planted in damp soil or sand. Whereas many shrubs and trees can be propagated by hard-wood cuttings, comparatively few can be grown from soft-wood cuttings. If the young green stems of most plants were planted in wet soil, even after the removal of their leaves, they would die, only a few, chiefly those with rather juicy or 'succulent' stems, being able to grow when planted in this way. Certain garden plants, notably the coloured-leaved *Coleus*, the Artillery plant (*Pilea*), the Wandering Jew (*Tradescantia*) and others are propagated in this way. Amongst farm plants, the sweet potato is the best example of this form of propagation, although the Hausa potato (*Coleus*) can also be propagated in this way if required.

Cuttings are often inserted in a slanting position in the belief that they grow more readily this way than when planted vertically. From the writer's experience there appears to be very little difference in results from the angle at which cuttings are planted, provided that they are kept moist and shaded, and that the soil around them is kept firm. Cuttings generally grow best when planted at the beginning of the season of active growth, which is at the beginning of the rainy season. In taking cuttings required to produce flowers or fruits, it is generally advisable to choose cuttings from the upper shoots which are more productive and yield earlier crops, than from the lower shoots, especially when the lower shoots are of the sucker type, such as in citrus fruits.

Some cuttings, for example the pomegranate, grow better when they are more than half-buried in the ground.

B. *Root Cuttings.* The roots of most plants if cut into pieces and planted will not grow, but will die and decay. A few plants, however, appear to have the property of producing new plants when their roots are cut or injured. The nim tree, for example, will produce new shoots from its roots when these have been cut with a hoe or a cutlass, and citrus fruit trees also seem to have this same ability. Occasionally one finds a tree which it is difficult to propagate in any other way. The breadfruit (*Artocarpus incisa*) is one such plant, as it does not produce seed, although a variety of it known as the breadnut tree can be grown from seed. The breadfruit tree cannot be grown readily from stem cuttings either, so that the usual way to propagate it is to make incisions into the root at some distance from the trunk. (Plate VIII *b.*) From these cut portions, new breadfruit trees grow, and when portions of the root to which they are joined are dug up, new plants can be obtained. Roots of some trees can be induced to develop active buds by exposing them to sunlight, and after this treatment it is usually possible to propagate from such roots. Such methods of reproduction are called root-cuttings, or sometimes 'root-suckers'.

C. *Leaf Cuttings.* A few plants can be propagated by leaves. The Life Plants (*Bryophyllum pinnatum* and *Kalanchoe spp.*) are the best examples and are common throughout West Africa; if partly buried in damp sand, or even left lying on the soil, they produce new plants from around the edges of their fleshy leaves. The *Begonias,* which are often grown as verandah plants in bungalows, can also be propagated from leaves grown in damp sand. If the leaves are large and fleshy, as they usually are, cuts are generally made across the main veins which are then pegged down in the wet sand. From these cut portions of the veins new *Begonia* plants arise.

Generally only plants with fleshy leaves can be propagated in this way, and only a few even of these can be propagated successfully by leaves.

2. Underground Stems

The difference between an underground stem and a root is that an underground stem contains buds and can give rise to new plants, whereas roots do not contain buds, and with a few

exceptions such as the one or two already mentioned they cannot give rise to new plants. Whereas roots often contain stored food, many underground stems are very rich in it, and are enlarged and specially adapted for the storage of large quantities of plant food, chiefly in the form of starch.

A number of farm plants are propagated by means of underground stems which are either planted whole as in tiger-nuts, Chinese yams, and Hausa potatoes, or cut into portions as in yams, ginger, and others. The various types of underground stems are grouped into botanical types which are described in the author's *West African Botany*, Chapter IV, 'The Stem'. Therefore full details of their structure will not be entered into here, but only examples of the various types will be given.

A. *Tubers*. The following farm plants are propagated by tubers: tiger-nuts (*Cyperus esculentus*), yams, and Hausa potatoes (*Coleus*), as well as Chinese yams (*Dioscorea esculenta*). Fuller descriptions of their appearance and actual method of propagation is given under each crop.

B. *Rhizomes*. Ginger and arrowroot are two crops generally propagated by portions of their rhizomes.

C. *Cormels*. Cormels are young small corms, produced around the edge of the original corm. The coco-yam is an example of a plant producing cormels which are used either for food or for propagation (see Fig. 16 *a*, p. 136).

D. *Bulbs*. Some plants, for example the onion, produce specially enlarged buds, enclosed in fleshy scale leaves or bud-scales which are enlarged and rich in stored food, chiefly in the form of starch and sugar. In the centre of the bud can be seen the short stem on which the young shoots and leaves grow. When onion bulbs are planted roots appear from the base of the bulb or the base of the stem in the centre of the bulb, while the upper part of the stem grows, producing leaves, a stem, and sometimes flowers and seeds, using the stored food in its scale leaves to begin such growth. Around the base of the original bulb in the shallot (*Allium ascalonicum*) new bulbs finally appear which are dug up as the leaves dry, and can be used for propagating in the following season. With the true onion (*Allium cepa*) the bulbs are large and are sometimes cut across the top before planting, to encourage them to produce more shoots. The shallot is often treated in the same way. True onions, unlike shallots, can also be propagated by seeds.

3. Suckers

A. *Suckers around the base of the plant.* Several farm plants are propagated in this way. Bananas and plantains are nearly always propagated vegetatively by suckers arising from the base of the original plant, although seed-bearing varieties of bananas are occasionally found in tropical Africa. These suckers are thick and contain large quantities of stored food, and can be left lying about for considerable periods of time without dying. Pineapples are also generally propagated by basal suckers, some varieties producing them more freely than others.

B. *Axillary suckers and 'crowns'.* The pineapple also produces suckers in the axils of the leaves, and at the base of the fruit as well. When planted these suckers will grow into new pineapple plants as will also the 'crown' or tuft of leaves on the top of the fruit, but none of these methods of propagation is as efficient and quick as propagation by basal suckers.

4. Layering

Layering is the term applied to the growing of stems or branches of plants in soil while these stems are still attached to the parent plant. This is usually done by pinning a stem down to the ground and covering it with soil. Sometimes an incision is made on the under-surface of the portion of stem buried, as this, by interrupting part of the flow of prepared food from the leaves to the roots, helps the stem or 'layer' to form roots. The purple and rose *Bougainvilleas* are sometimes propagated in this way, while amongst farm plants the breadfruit can also be grown if carefully layered and the stem 'nicked' in the way described. When the layer has produced roots and is beginning to form a proper plant of its own, it is usually severed from the parent plant and replanted in a pot, or moved to a permanent position elsewhere. When the stems are not near enough to the ground to be pegged down and covered with soil, the soil is sometimes carried up to the branch and wrapped round it to induce it to form roots. This more specialized kind of layering is known as 'marcottage', and in India as 'gootee layering' and has been practised with mangoes in India and China for centuries. Sometimes a bamboo pot containing soil is supported under a suitable branch which is inserted into the side of the pot through a slit. A portion of the branch is cut half-way through and kept covered with the soil in the pot and watered until it forms roots. Another method is to choose a

healthy branch where the wood is well ripened, and make a deep slanting cut upwards in the neighbourhood of a node or leaf-bud. This incision should be kept open with a piece of stick, or sometimes the stem is 'ring-barked'; that is a small ring or circle of bark is removed with a knife. A handful of good soil, preferably rich in humus, is then taken, moistened, worked into a sticky mass, and then wrapped round the stem in the region of the incision. A piece of sacking or fibre is wrapped round the soil to keep it in position and the whole lot is made firm with string or fibre tied round it. A tin or bamboo pot is then tied on a branch above it, and a hole is made in the bottom. A piece of string or thin rope is put through the hole from the outside, and a knot made so that it fits closely against the hole inside the vessel. The string is then carried downwards and wrapped several times round the 'gootee'. The vessel is then filled with water, which drips slowly along the string from the bottom of the vessel, and around the 'gootee', keeping it moist. If the vessel is kept supplied with water from time to time, the cut portion or layer inside the sacking gradually produces roots after a few weeks and can then be cut off from the parent tree, planted in a special pot, or put in its permanent position. Gootee layering is best done in the rainy season when the sap is up and trees are in active growth. Nutmeg, breadfruit, and other trees can be propagated in this way, and, in the case of mangoes, it is a much safer way of producing trees from which a good quality of fruit can be expected.

5. Bulbils

A few plants are able to produce curious vegetative growths known as bulbils. Some yams, especially the bulbil-bearing yam (*Dioscorea bulbifera*) and also some of the water yams, can produce such bulbils in the axils of their leaves (see Figs. 14, 15 *b*, p. 132). The sisal hemp and the Mauritius hemp are both able to produce bulbils on their flowering stems. These are produced in great quantities, and resemble tiny hemp plants with leaves and sometimes even with small roots. Finally they fall to the ground where they quickly take root and grow.

The aerial bulbils of yams are rich in stored food (*starch*) and when planted shoots appear on their surface and new yam plants grow from them.

In propagating plants two excellent home-made appliances

can be used. In planting seeds, especially those requiring particular care, or seeds so small that they are liable to be washed away in ordinary nursery beds, it is often best to plant them in special seed boxes, known as 'seed flats'. As wooden boxes so often split or leak, or are consumed by termites, a satisfactory flat can be made by cutting a petrol or kerosene tin in half, longitudinally, when two flats can be obtained. (Fig. 31 *a*.) In the bottom of each flat, holes are made and after a layer of small stones has been put at the bottom to assist in drainage, good

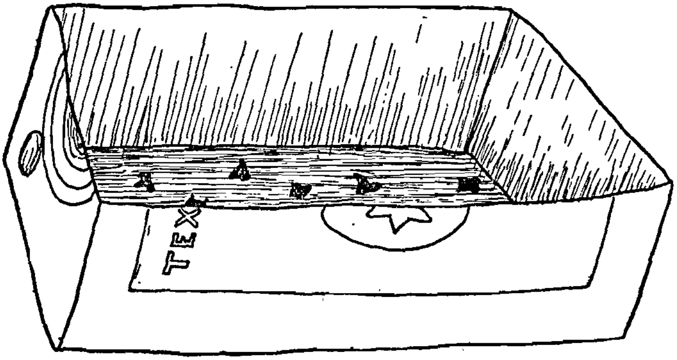

FIG. 31 *a*. Seed flat made from petrol tin.

rich soil is put on top and the seeds are planted in it. Such flats can be kept in a shady place or in a garden shed and watered carefully. When the seedlings are large and strong enough they are transferred either to a proper nursery bed or to bamboo pots.

A bamboo pot is another useful article in the school garden or nursery and is easily made by cutting a large stem of bamboo into sections of any height from 6 to 18 inches, so that a node or division is included at the bottom of the pot. (Fig. 31 *b*.) At this node is a cross-layer which acts as the bottom of the pot. This layer, or 'septum', should be pierced with a hole in the centre, and after pebbles and soil have been put into the pot, the seedling or seed is planted in it.

These bamboo pots are very useful as they are so easy to make and to handle. When the plant is ready to be planted in its permanent position the bamboo pot is split with a longi-

tudinal blow of the cutlass down each side, dividing the pot into two parts with a wad of soil enclosing the plant left lying in the centre. This is easily removed with the hands and planted in the hole prepared for it. The plant in its pot can even be planted in the hole and then left, after which the pot either rots away, or is consumed by termites.

Fig. 31 *b*. Bamboo pot.

BUDDING AND GRAFTING

Most fruit trees grown on West African farms are raised from seed. As we have seen in the section on 'Sexual Reproduction of Plants', seedling plants are extremely variable owing to the mixed ancestry and characteristics of the former generations from which they are descended. One way of overcoming such variability is by the process of selection, but this is a slow method when we want to improve perennial crops such as fruit trees.

Take, for example, a typical West African plantation of sweet orange or grape-fruit. Every farmer knows that his trees vary greatly, even if all were originally grown from seeds from one tree. Some are mature earlier in the year, or bear fruits a year or more earlier than others. Some have heavier yields or are hardier than others. Some have thinner rinds, larger or sweeter fruits, than others. A wise farmer should number his trees and keep records of all these facts about his trees until he knows which are his best trees and which are his poorest.

After collecting all these details about the trees in his orchard, the farmer can then set about improving his plantation. If he plants seed only from his best trees, he can gradually cut out his worst trees and replace them by seedlings of good trees. Even then there is no guarantee that such seedlings will breed true, although many of them may do so, and continue to bear excellent fruit for a number of years.

Eventually, however, as we saw in the chapter on 'Citrus Fruits', most seedling trees of sweet orange, grape-fruit, and even limes, generally succumb to a disease known as gummosis, which usually begins to appear six or eight years after planting.

To avoid both these troubles, first the great variability of seedling trees, and secondly their early death from gummosis, quicker and surer methods of propagating them by *vegetative* means must be adopted. These methods of propagation are known as budding and grafting. The main principle underlying both methods is that a strong and hardy type of plant is chosen as the *stock* plant, on which the buds or grafts are put, whereas the buds or grafts themselves are taken from the plants of superior quality which are generally less hardy, and they are known as *scions*. The result is, therefore, that buds or stems of improved, higher quality scions of various fruit trees, though they are delicate, are made to grow on the stronger and hardier stocks of fruit trees of inferior quality.

Take the orange tree, for example. The sour or Seville orange is chosen as the stock, because it is hardy and a strong grower. Its fruits are sour and less pleasant to eat than those of the sweet orange, but the sour orange tree is immune from gummosis, whereas the sweet orange, grape-fruit, and other finer quality citrus fruits are susceptible to it. Therefore seedlings of sour orange are grown in the nursery, or where seeds of sour orange cannot be obtained, seeds of the rough-skinned lemon can also be used, as they are also said to be resistant, although some have been known to die from gummosis on the Gold Coast. These seeds, which should be selected from the healthiest possible trees, should be sown in rows in the nursery, leaving about 1 inch between each seed, and in rows 9 inches to 1 foot apart. The seedlings should be shaded and kept well watered, and then when about 6 inches high they should be transplanted into larger beds, in rows 3 feet apart and 18 inches between each plant. Only the best seedlings should be transplanted and those with twisted or poor tap-roots, or with other defects, should be discarded. The seedlings are allowed to grow until the stem is about as thick as a lead pencil, when they are ready for budding.

In cases where a limited number of good plants are wanted for a garden it is advisable to establish seedlings in pots made from bamboos or kerosene-tins ready for budding when sufficiently developed.

Care should be taken to select the budwood from the best possible plants. When introduced varieties, such as Mediterranean Sweet, Washington Navel, or other varieties from the United States or from Mediterranean countries are available in the country, budwood should be taken from them. Several

attempts have been made to send special budwood, packed carefully in damp moss, to West Africa from Palestine, United States, or elsewhere, but the cuttings are nearly always dead or practically dead and useless on their arrival. If budwood of such varieties cannot be obtained, it is often possible to obtain budwood of the best varieties in the country from agricultural stations or even from farmers who keep records of their trees and know definitely which of their trees are earliest in maturing, are most free from seeds, and have fruits of the best quality. Such budwood is taken when the buds are well developed, which is generally at the beginning of the rainy season, and the budwood chosen is generally about the thickness of a lead pencil.

Budding is best done at the beginning of a growing season, either at the beginning of the large or small rainy season. A budding-knife is used and consists of a short sharp blade, pointed at the end, while the handle is generally composed of bone and has a somewhat sharpened edge at the end so as to enable the bark of the stock to be pushed back without injuring it, before the bud is inserted. If a special budding-knife is not obtainable, an ordinary sharp penknife will do quite well.

For budding citrus fruits the 'T' method is usually carried out. (Fig. 32.) A T-shaped incision is made with the budding-knife in the bark of the stock plant (sour orange) at about 8 inches above the ground. The vertical slit, about 1 inch in length, is first made in the bark and a short cross-cut is made on top. The reverse or bone end of the budding-knife is next pushed into the T-shaped incision to force back the bark slightly so that the bud can be inserted more easily.

Then the budder, who carries a supply of budwood around with him, as he goes from plant to plant, selects a well-formed bud and with his knife he slices off the bud, together with some of the wood as well. The small slice of wood is then carefully removed from the bark, taking great care not to injure the bud as the wood behind it is taken away. The bud is then trimmed to the right size with the budding-knife, most of the bark above and below the bud being cut off until only the bud and about 1 inch of bark is left. Then, holding back the incision on the stem of the stock plant with the reverse end of the budding-knife, the bud is pushed into the top of the slit, and carefully pushed down until it is in its final position, after which the stock above and below the bud is tied round firmly with raffia, leaving the bud itself exposed.

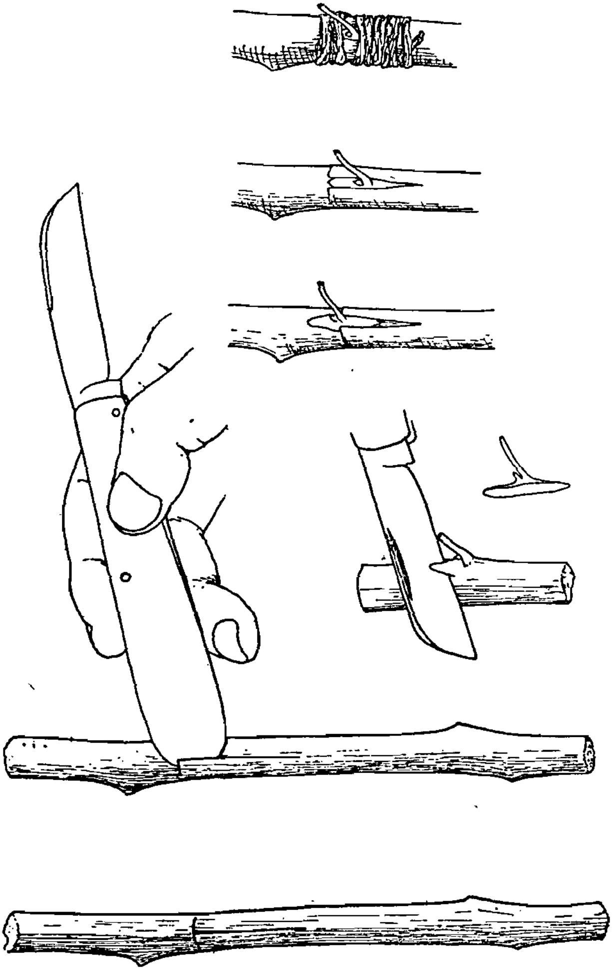

FIG. 32. Diagrams to illustrate method of budding citrus fruits.

The process is so simple that one soon becomes proficient at it. A good supply of seedling sour orange-trees should be kept in school gardens so as to give the students a good opportunity of practising budding.

Sometimes special wax, known as grafting-wax, is added, and helps to keep the incision round the bud water-tight, as well as preventing fungus spores from entering. Grafting-wax can be bought, but perfectly good results are generally obtained without it.

After the bud has been inserted and then tied up with raffia it is left for two or three weeks to see whether it will 'take'. At Aburi Gardens on the Gold Coast 85 to 90 per cent. of the buds had become green and plump after three weeks, even without the use of grafting-wax. When they reach this stage, the raffia fibre is removed, and the stock plant is pruned well back. The bud soon begins to grow and produces a stem and leaves. This young scion will soon grow into the main part of the fruiting tree, sweet orange or grape-fruit, as the case may be, growing on a strong and hardy root-stock of sour orange. When the young shoot is several inches long, the remaining stem of the stock plant is cut back flush with the scion, and then tarred over. Sometimes the young budded tree is tied to a stake to help it form a good shape, but this is not always necessary.

Care should be taken to remove all buds or shoots on the stock *below* the special bud or scion, as such lower shoots would grow into basal suckers and utilize the sap which should be encouraged to flow into the scion.

When the scion is thoroughly established on the stock and the budded tree is between 2 and 3 feet high, it is ready for transplanting to its permanent position on the farm.

Although in West Africa budding is generally only practised on citrus fruits, other tropical fruit trees, such as mangoes, Avocado pears, and cacao can be, and have been, propagated in this way. Also various flowering shrubs, such as the Hibiscus (*Hibiscus rosa-sinensis*) are sometimes budded, even so that shoots bearing yellow, pink, white or double flowers can be grown on the common single red variety. Also in the same way a sour orange-tree can be made to bear branches producing grape-fruit, sweet orange, lemon, and lime respectively.

Grafting

Just as budding is the growing of a bud of one type of plant

(the scion) on to the stem or stock of another plant (the stock plant), so grafting is the growing of a whole shoot or stem (scion) on another plant (the stock). Grafting is practised on a large scale in temperate Europe and in America with rose-trees, apples, and other fruit trees. In the tropics, however, budding is practically the only method of grafting used, and it is sometimes called 'bud-grafting'.

'Grafting by approach' has already been described with reference to the mango, with which it is sometimes used (see Fig. 24, p. 225). The other common methods of grafting, such as crown, cleft, and saddle-grafting, commonly described in horticultural books, are so rarely used in West Africa that they will not be described further here.

CHAPTER XXXI

THE STORAGE AND TESTING OF SEEDS

The vitality of seeds

A SEED, although it may appear to be dead and lie on the floor of a room or in a box for weeks or even months, has the power of springing into life and growth as soon as it is planted in warm damp soil. This power of springing into life and growing when it gets the right conditions is known as 'vitality', and all seeds possess this power to differing extents. Some seeds can remain 'dormant' or asleep for fifty or a hundred years, or even longer, germinating finally when they are given the moisture and warmth that they need. Others can only remain alive for ten years or so, others for five, and others again for only one year or even less. Their length of life depends largely upon the vitality or hidden life force that is contained in them. The longer seeds are kept without being planted, the weaker becomes their power of germination later on.

All seeds contain a certain amount of water locked up inside them, and as long as they do not lose this water they generally do not die. The majority of seeds are surrounded by a waterproof coat which prevents the seed inside from becoming dried up. These waterproof coats are of various thicknesses, those of beans, for example, being quite thick and leathery when compared with those of grass seeds. Just as these seed-jackets prevent water from escaping from the seed inside, so they tend to prevent water outside from entering the seed itself. How then does the water in the soil enter the germinating seed and swell it until its bursts its waterproof coat? The answer is that it enters through a tiny hole which in peas and beans can be seen near the scar on the seed. This hole is very small, often no larger than a pin-prick, but it is through it that water mainly enters and helps the seed to germinate.

When seeds are kept in storage, air gradually enters this small hole and decreases the vitality of the seed within. When seeds are kept in damp places, even if they are put in a dry but open box in a room where the air is moist, the moist air enters the seed through the small hole and this has a bad effect on its vitality. Where mouldy seeds are kept together with healthy ones, the spores or tiny 'seeds' of the mould float about in the air and are so small that they enter the holes in the seed-coats

of healthy seeds, and decay quickly sets in. That is why we often find seeds which appear normal on the outside, but when we press them we find the inside to contain nothing but a grey or yellowish powder. Diseases have entered the seed in the way described and destroyed the structure and therefore the life of the seed.

Of course moisture can penetrate to some extent through the seed-coats themselves, so that, generally speaking, those seeds with thick coats have more vitality than those with thin coats. The seeds of mango, for example, quickly lose their vitality when removed from the ripe fruits. Unless planted almost at once, after a few weeks they will be found to be quite dead, with only a grey powder in the centre.

Tomato, pepper, and garden egg seeds also lose their vitality quickly. Their seed-coats are comparatively thin, and, especially if they are kept in places that are at all damp, they soon lose their vitality, and even if kept under quite dry conditions for two or more years and then planted, only a small percentage of the seeds will germinate. Generally speaking, the seeds of most farm plants have short vitality and should not be kept for more than one season.

Therefore to ensure the proper vitality of farm seeds care must be given to two details, first the harvesting and second the storing of seeds. Sometimes seed which appears normal may have the embryos either under-developed or entirely absent, due to imperfect fertilization.

Much harm is done to the vitality of seeds during the time of harvest. Much depends upon the weather at that period, as also upon the weather the crop has had during all stages of its growth. If the crop has had a good growing season and the seeds are large and well filled out they will have more vitality than those of a crop which has been grown in a poor season and which has thin, poorly developed seeds. Weak plants cannot produce seeds of high vigour for, although such seeds may appear normal when harvested, they lose their vitality quickly during storage. Under-ripe seeds also lose vitality much quicker than fully ripe ones. It is most important that the weather at harvest time should be dry. The ripening of such seeds as those of Guinea corn or bulrush millet, for example, is sometimes ruined by damp weather during the harvest. Moulds of several kinds grow on the ripening seeds in the warm moist atmosphere, so that they are sometimes ruined for use as human food, as

well as being useless for planting in the following season. While warm damp weather at harvest time tends to weaken and sometimes destroy the vitality of the ripening seeds, farmers can often prevent this happening by proper care. Seeds of farm crops should not be allowed to lie on the ground in the harvest season, as the mere contact with the warm moist ground may stimulate their germination and so destroy their vitality. If the weather at harvest time is unsuitable, the seeds should not be allowed to stay in the field for indefinite periods, but should be picked and dried artificially if necessary. In continual damp weather seeds which are otherwise absolutely ripe can be dried by slow heat near the fire indoors or in the farm shed. They should be kept on boards, old tins, pieces of old corrugated iron, or anything of that kind, so long as they are not put on the damp earth. During brief spells of sunshine they can be laid out in the sun and dried, but should be brought in under shelter as soon as rain is threatening. Careful drying or curing or seasoning of seeds is therefore very important before storing the seeds. One or two soakings of rain, even though the seeds are dried again afterwards, weaken their vitality considerably.

The next important detail is the storage of seeds. Many farmers leave their seeds lying in heaps on the floor or in sacks, bags, tins, or open boxes. The damp air is able to reach them and their vitality is slowly weakened. Farm seeds should always be stored in closed dry receptacles, preferably of metal, as these can be kept drier than those made of wood. They should also be kept in a cool situation. Also rats and mice cannot enter metal receptacles, whereas they often gnaw holes in wooden boxes. If possible these covered tins or boxes should have air-tight covers. This prevents the moist air from entering and weakening the seeds' vitality, and also prevents the spores of diseases from attacking the seeds. Many foods are sold in tins with air-tight lids, and these tins should be kept for storing seeds. Flour tins, custard tins, cocoa tins, screw-top and clip-top jam-jars could all be used for this purpose. If these are not obtainable empty cigarette tins, biscuit tins, and other tins with more loosely fitting lids could be used. If the seeds are kept covered up this also prevents rats and mice, ants, beetles, and cockroaches from entering and destroying the seeds.

Even when seeds are carefully stored in air-tight tins in the way described, they are often found to be badly attacked by

weevils when the tins are opened some time later. Although weevils have not been able to enter the tins, some few were in the seeds when they were first sealed up, and they soon attacked the remainder. Such weevil attacks in sealed tins can either be prevented when the seeds are first stored, or cured when the damage is discovered, by either of the following methods.

First the seeds are wrapped in a piece of cloth about the size of a handkerchief and immersed in absolutely boiling water for a few seconds. This kills the weevils present and, provided that the immersion is not too long, it has little effect on the vitality of the embryos. Seeds treated in this way should naturally be carefully dried afterwards before storing. The second method is to pour on to the seeds a few drops of carbon bisulphide, a thick, oily, and evil-smelling liquid obtainable from drug stores. The tin should be closed up at once, when the liquid quickly evaporates and the gas given off penetrates everywhere in the tin and kills all weevils present. As carbon bisulphide is highly inflammable, care should be taken that no naked flame is brought near it. Naphthalene can also be used to prevent and kill weevils in stored seeds. Carbon bisulphide and naphthalene have very little effect on the germinating power of seed treated by them, and if the seed is carefully aired and dried after having been treated, practically all traces of the smell and gas can be removed and the grains are then fit for use as food.

On many African farms the farmers have an interesting way of storing their corn cobs in small huts on four upright posts, beneath which they often light fires. This method keeps the corn dry, but only partly assists in keeping weevils away, while rats and mice can often enter.

The dried seed should be removed from the cob before it is attacked by weevils, and if air-tight tins are not available, and if the seed is of good quality, and especially if it is to be kept or sold for seed purposes, it can easily be stored in empty petrol or kerosene tins. These can easily be made air-tight by replacing the lid and sealing around it with solder. Corn seeds kept in such tins will last much longer and be quite free from weevils and disease when opened, provided that the tins are kept in a dry place.

In fairly large farms it is worth while to make large metal receptacles for holding seeds. These are known as bins, and can be made easily by constructing a framework of wood and covering it over with sheet zinc, or even corrugated iron sheets, which

should be properly joined together. A hinged, metal-covered, and close-fitting lid completes the bin and prevents the entry of rats, mice, and insects, while at the same time the seeds can easily be removed at any time, great care being taken to keep the lid closed when the bin is not in use. These bins are common on many farms all over the world and could be used on West African farms with very little extra expense. They are very useful when corn is constantly required, either as human food or for the feeding of poultry or other stock.

Those people who buy selections of seeds from European seedsmen have probably noticed that they come out in tins which are carefully sealed and so made air-tight. If they arrive several weeks before it is time to plant them, it is unwise to open these boxes, as the vitality of the seeds is greatly weakened in consequence. They should be kept until ready for planting and then the seal should be broken, and the seeds planted as soon as possible afterwards.

Where imported seeds are sold in stores, the small paper packets containing them are generally kept in large glass jars with screw-top or air-tight lids. In this way they can retain their vitality much longer than if they were kept loose in drawers or boxes.

The Testing of Seeds

There are several causes which prevent seeds from germinating and great care should be taken when buying seeds to make sure that they are sound. Several defects can be noticed by a careful examination of the seeds. Sometimes much rubbish is included with the seeds, and when the farmer buys one or two pounds or measures of seed it may contain a good quantity of impurities such as sand, gravel, and broken pieces of stick and other debris.

Secondly, the sample of seed may contain weed seeds and other seeds mixed up with it, and where the weed seeds closely resemble the seeds of the crop in question it is often difficult to distinguish between them. Such impurities can often be seen by spreading the seeds out flat on a piece of paper and picking out the weed seeds and other trash.

Thirdly, samples may contain some seeds which are not fully mature or filled out, and which therefore will either not germinate at all, or germinate poorly. Such seeds are often picked

before they are fully ripe or as the result of a poor season in which they have not been able to mature to the full.

One of the commonest troubles with seeds stored on African farms is that they are riddled with weevils, and sometimes 75 per cent., or even more, have their embryos eaten away by these destructive beetles which could have been prevented from entering had the seeds been stored properly to begin with. The longer they are kept, the more the seeds are attacked, until when the time comes for planting, the seeds sold in the market are so ruined by weevils that only two or three in every ten will germinate. This means a very heavy loss when reckoned in in money, and means that the farmer has to sow three or four times as much seed as he would otherwise if he had clean and well-stored seed.

Lastly there are the seeds in every sample which are attacked by disease. Often they can be distinguished readily, covered with mould or mildew, thus spreading the disease to the healthy seeds. Sometimes the seeds appear to be sound externally, but when they are pressed with the fingers, they are found to be quite hollow, with a powdery substance inside. At other times the seeds appear healthy, but when they are planted the spores of the diseases are stimulated into growth by the heat and moisture, and the seed is destroyed by mould or mildew before it is able to germinate.

Most of these faults, however, can be seen with the naked eye, or by feeling the seeds with the fingers. Often old or slightly mouldy seeds can be distinguished by smelling them, when they have an old and musty smell and therefore should not be bought or used. Old seeds can also sometimes be judged by the dull appearance of the seed-coats. Fresh seeds generally have bright and shining seed-coats, but they become duller as the seeds grow older. Unscrupulous seed merchants in some countries actually polish samples of old seed by stirring them up violently, with sand or other materials, until the seed-coats become bright again and the seeds appear to be fresh.

The only sure way to be certain that a sample of seeds which otherwise appears to be sound is fresh and will germinate is to test them by some home-made tester.

Two of the simpler methods, known as the rag-doll seed tester, and the plate-and-saucer seed tester, are described and figured much more fully in the author's *West African Botany*, to which the reader is referred.

Generally speaking the system is to take a chosen number of seeds taken from the sample, say 10, 20, 25, 50, or 100, depending upon the size of the seeds or the number in the sample. These are wrapped up in a cloth which is kept moist, or placed in moist cloth or blotting paper between a plate and saucer, in the bottom of which a supply of water is kept. The seeds are removed and counted as soon as they germinate, and after a week or ten days the seeds which still remain may safely be classed as sterile, diseased, decayed, or immature, or of such poor vitality as to be quite unsuitable for practical purposes. The speed at which the seeds germinate can also be judged. When the sample consists of fresh seeds they will probably germinate mostly in the first four or five days, while, if the sample is older they will take longer, and therefore be judged as less suitable for good farming purposes.

As more attention is paid in West Africa to the planting of good seeds, seed testing will be carried out by farmers on a much wider scale, while to-day it is hardly used at all, except in the more progressive schools by keen teachers.

Seed selection

Seed selection is of vital importance if the best possible crops are to be raised, as the best seeds are mainly produced by the best plants.

The best possible way of practising seed selection is to buy seed from recognized seed merchants who have grown plants for generations with great care and only chosen the best seed from each generation. As long as there are no proper seed merchants in West Africa, the best seeds can be bought from seedsmen in Europe, America, South Africa, or India.

Of course seeds of some crops such as rice, Guinea corn, and millet and other annual crops cannot be obtained from England because they are not grown there. Others, such as tomatoes and French beans, which can be bought from English seedsmen, do not do well in West Africa, where the climate is so different, so that it is often better to obtain such seeds from recognized seedsmen in South Africa or the Southern States of America, where the climate is more like that of West Africa.

There are seeds of many plants grown in West Africa which cannot profitably be bought elsewhere, either because they are unobtainable, or because it would be too costly to buy them in

the quantities required. Therefore, for most West African farm crops, the solution is in careful seed selection on West African farms themselves. Farmers must become their own seedsmen, for the present at least, or set up as small seedsmen for their own district.

A farmer can begin by refusing to plant any except the very best seeds, such as the largest ones and those without weevils. When his crop is ripe he can go round and pick his seeds for the following season from the largest and healthiest plants producing the heaviest crops. These he can keep apart, dry carefully, and store in air-tight tins or bins, while he uses the remainder of his crop for food, or for sale. In the following rainy season he once more plants only the largest and healthiest of his selected seeds, and at harvest time again he selects the seeds from his healthiest plants. If this process is carried on carefully for only two or three years, for example, the farmer can double, treble, or even quadruple the yield of his crops, which are not only larger, but healthier and more able to withstand the attacks of insects and diseases than those of his neighbours. If he carries on his method of seed selection for more than three years, the results will be more lasting, and although he will not continue to improve his yields to the same astonishing extent, his seeds will improve in average quality and yield. Neighbouring farmers will soon notice the results and will be ready to buy his seeds which he can sell at a higher price than the local market price and, as time goes on, he can be more and more sure of getting higher prices for his seed. It is most important, however, that once a farmer starts this system of seed selection he does not relax, for years of work and progress can be wasted by one or two years of carelessness and neglect. The quality of the seeds raised can quickly go back to the original low level if careful selection of the best seeds does not take place.

This is why many European and American farmers buy fresh stocks of seed from seed merchants every year or two. If they continue to plant their own seed without selection every year the quality and yield of their crops soon grow less, and the easiest way to keep the quality high is to buy from seedsmen, whose job it is to keep selecting continually and so keep the level high.

If educated farmers in West Africa would only practise the selection of their own best seed from year to year, a very big difference in some of the farm crops grown could be noticed in

a comparatively short time. A good start can be made with maize, or corn, which is of very poor average quantity in West Africa and much inferior to South African or American corn. Corn would quickly show results if careful selection was practised with it, and then a start could be made with other of the main West African annual crops.

CHAPTER XXXII

INSECT PESTS

EVERY one is familiar with the diseases which insects carry and which affect man. Amongst them are malaria and yellow fever, which are carried by mosquitoes, and sleeping sickness by tsetse-flies. Similarly the amount of damage done to man's food and other crops by insects is enormous and amounts to millions of pounds every year. Wherever crops are grown singly and in vast areas, as happens so often in Europe and America, and in other parts of the World, an insect pest rapidly spreads throughout the whole area and is then very difficult to cope with. Insect pests on cacao, for example, have spread rapidly through the large areas devoted almost entirely to cacao on the Gold Coast. The yam beetle, which appeared a few years ago in the Niger Provinces of Southern Nigeria where yams are so largely grown, spread with alarming rapidity, practically ruining the yam crop for a year or two and causing great distress to farmers. This beetle also occurs on the Gold Coast. Much damage has been caused to the cotton crops in Nigeria by insect pests, and citrus fruit plantations in the Gold Coast and Sierra Leone have also recently been heavily attacked by citrus moths, which often ruin most of the fruit.

Occasionally an outbreak of a particularly destructive and widely spread insect pest occurs. The migratory locust is perhaps the most striking example of this. This insect, which normally behaves as an ordinary grasshopper and is confined to limited areas known as permanent breeding areas, under certain climatic and other conditions changes into another completely different phase, known as the migratory phase. These migratory locusts are brown or yellowish in colour and migrate in huge swarms consisting of millions of individuals. During the last five years (1928–33) they have spread over the whole of tropical Africa.

Although these insects and the more destructive 'hoppers' are essentially pests of graminaceous crops, or members of the grass family, such as rice, maize, Guinea corn, millet, sugar-cane, and bamboos, they also occasionally attack the leaves of bananas, plantains, and palm trees, when they invade the forest belt during periods when their normal food is scarce.

Fortunately these locust attacks, although very serious and

causing famine in some districts, are periodical and only last for a few years every twenty or thirty years or more.

On the whole the West African farmer's method of mixed cropping, or growing two or more crops on the same piece of land, is not so favourable to the unrestricted attack of insect pests as the more European method of single cropping on larger fields. The European method of crop rotation helps to prevent the pest from becoming too much established in a field and the African method of shifting cultivation also has the same effect. Nevertheless, as already pointed out elsewhere in this book, the African farmer is bound to go in for more pure stands of crops as he develops his export or 'money' crops, and he is more liable to give up shifting cultivation in favour of crop rotation as land becomes scarcer and population increases, so that insect pests are apt to become worse instead of better in West Africa in the future. Therefore, the need for a knowledge of them will be of increasing importance.

Where crops are weak or unhealthy, whether due to poor soil, bad cultivation, overcrowding, or to excess of rain or drought, insect pests tend to cause more trouble. Where the natural vegetation has been interfered with by cutting down the forests, the climate is sometimes affected, but what is more important is that the whole *balance of life* has been upset by such destruction of the original vegetation. Therefore under the new conditions a violent struggle for existence takes place and certain weeds, insect pests, and other forms of life thrive unduly until a new balance of life is gradually set up.

Two other explanations for the sudden appearance and spread of insect pests are either that the insect itself, or the crops on which it feeds, are not natives of the country, but have been imported. Great trouble has been caused by sudden outbreaks of insect pests caused by the importation of these insects, in the egg, larval, pupal, or even the adult stage in soil, in packing materials, or in seeds, fruits, or on whole plants. These insects, finding themselves in new countries where their old natural enemies do not exist and where their new enemies are few, sometimes spread with amazing rapidity. Some of the worst insect pests in the world are not natives of the countries in which they flourish. For this reason in most countries where agriculture is given proper consideration there are special laws against the importation of soil or plants from other countries, unless certain conditions are complied with, and if West Africa is to prevent

such outbreaks it should also follow by passing and enforcing such laws.

Similarly, the introduction of new plants or crops to a country, especially where an introduced crop is grown at all extensively, sometimes results in an outbreak of certain insect pests on this new crop. Just as some introduced crops seem to be particularly hardy and free from enemies, others are particularly susceptible.

Any one who has attempted to deal with any single insect pest will soon realize how helpless man is in trying to deal with and control the teeming insect life around him. The leaves, stems, or fruits of his crops may be largely destroyed by one or more types of insect, and he is faced with the problem of its control. Many facts have to be collected about the insect or insects in question before he can proceed at all. First he must know the true identity of the insect. If he knows its family or group he may more easily have some idea of its habits. The advantage of knowing the identity or scientific name of the insect is that one can then look up other literature and one can sometimes find out what other workers have discovered about its life-history and habits and how to control it. Then there is the difficult question of its life-history. The insect, say a beetle boring into the stems of a crop and ruining it, may be almost impossible to deal with in this, its adult stage. If, however, during a study of its life-history, one discovers that during its larval stage it is always found in rotten wood or some such place, as the coconut rhinoceros beetle, one can attack it in that stage by burning or destroying all the rotten wood in the immediate neighbourhood. In other words, a knowledge of any destructive insect's life-history gives one an idea of the vital moment at which one can attack it with most hope of success. The most vulnerable point in the insect's life is taken advantage of by man, who wages war against it, sometimes with poisonous gases, dusts, or sprays. Another method, known as biological control, is used nowadays more and more and consists of the encouragement of the natural enemies of the insect pest in question. This is done either by breeding its local enemies or by importing them specially and then releasing them to wage their own and often successful war against the particular pest. In practice the imported enemies have generally proved more successful than those already in the country.

The whole subject of insect pests is so huge that only an

attempt to mention the main types of pests will be made here. The life-histories and methods of treating any *one* of these, or others like them, can often be found by writing to or visiting agricultural entomologists, who spend all their time trying to deal with the innumerable insects doing damage to agricultural crops in West Africa.

Insect pests are generally divided into two main groups—namely *biting* and *sucking* insects, depending upon whether their mouth-parts are biting, in which case they *eat* the host plant, or whether they have sucking mouth-parts, in which case they *suck* the juices of the host plant.

1. Typical Biting Insects

Biting insects are of several kinds. For example, in some types only the larvae use their biting mouth-parts to attack crops and in others only the adults.

(*a*) *Caterpillars*. Although all moths and butterflies, into which caterpillars finally grow, have only a sucking mouth-part, or proboscis, many of their larvae or caterpillars do tremendous damage to crops, mainly by consuming their leaves. The caterpillar of the cabbage butterfly, for example, eats the leaves of cabbages and often ruins them for selling purposes, whereas the caterpillar of a yellow and black swallow-tail butterfly does much damage by eating the leaves of citrus fruit trees. These caterpillars, being of the same colour as the leaves of the citrus fruit trees, are almost impossible to detect amongst the foliage.

(*b*) *Beetles*. (i) *Biting beetles*. There are many beetles which attack and eat the leaves, flowers, or fruits of farm crops. The leaves of cucumbers, pumpkins, and other members of the Calabash family are generally riddled with holes made by beetles of this kind, just as seedling citrus fruit trees are often attacked by a small black beetle with an orange spot on each wing-case.

(ii) *Boring beetles*. These are even more numerous, or certainly more destructive to crops than biting beetles. In the case of beetles which bore into the stems of plants, the damage is generally done by the larvae. These beetles eat the juicy centres of the stems as they go, weakening the whole plant, and sometimes leaving the stem so weak that a strong wind snaps it off. Typical examples of borers are the palm weevil and the stem borers of cola and coffee. The large black beetle known as the rhinoceros beetle (Fig. 33) is another example of a boring beetle,

although it cannot be classed as a proper stem borer. This insect bores into the juicy growing-point of the coconut palm, and unless killed it destroys the whole terminal bud, which is the only bud a palm has, so that the palm dies.

The numerous types of beetles known as weevils which attack stored seeds of all kinds, as well as stored produce, are other examples of boring beetles. The method of preventing seeds from being attacked by weevils has been described in the chapter on 'The Storage of Seeds'.

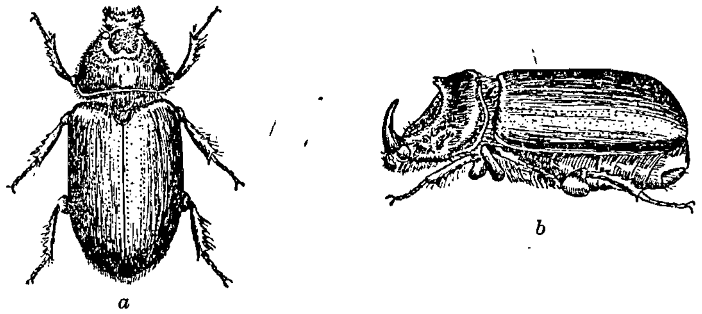

FIG. 33. Rhinoceros beetle—a pest of coconuts. (*Oryctes monoceros.*) (*a*) Female. (*b*) Male.

(*c*) *Members of the Locust Family.* This family of insects have biting mouth-parts and do a great deal of damage to crops. The migratory locust is probably the best known and most destructive member of this family and has already been described. The mole-cricket is another, and crawls out of its hole in the soil at night-time, biting off seedlings of all sorts, just above the level of the ground.

This is a brief description of some of the commoner biting insect pests, and as most of them bite off and consume the leaves or other portions of plants, one method of dealing with them is to poison their food—in other words they are generally killed by the use of *stomach poisons.* These stomach poisons are generally chemical compounds which must do no material harm to the plants to which they are applied and be deadly poisonous to all insects which eat them, even in small quantities. Care must be taken not to apply poisons which will 'burn' the foliage, as then the insecticide will have a more harmful effect than the

insects it is expected to control. When the leaves or fruits of a crop are to be consumed by man later on, they should be washed carefully so that all poison is removed before they are eaten. The burning effects of insecticides are much more important than the possible effect of poisoning humans.

It is essential to know when, and in what quantity, to apply arsenical insecticides. A safe formula to use is as follows:

Spray. Lead arsenic (basic) paste, 4–6 lb. (depending on delicacy of foliage), or lead arsenic (basic) powder, 2–3 lb.; water, 100 gallons; slaked lime, 3–10 lb. (the larger quantity for delicate foliage).

Dust. Finely powdered lead arsenic (basic), 1 lb.; dry powdered air-slaked lime (or other neutral carrier such as low-grade flour), 6–20 lb.

These poisons are applied either as dusts or as sprays. 'Dusts' are shaken on to the leaves of the plants either after rain or in the early morning when the dew is still on the leaves. Such dusts can easily be applied by putting the powder into small bags made of sackcloth and shaking the bag over the plants, for instance over young pumpkins or cabbages, when the powder readily sticks to the damp leaves. A spray is applied to the plant by means of a sprayer which covers the plant with a fine spray. After it has dried the poisonous chemical is left evenly distributed and in a fine state on the leaves. Sprays are generally much more effective than dusts. Dusts are used in preference to sprays when there is no ready supply of water. Sprays are often dependent on soap solutions to make an *emulsion*, whereas dusts are dependent on a carrier, consisting of a light material such as finely divided slaked-lime or flour.

The boring insects cannot be killed with sprays and dusts. They can be killed either by thrusting bent wires down their borings, as with stem borers and coconut rhinoceros beetle, or by cutting off the stems or branches in which they occur and burning them.

Mole-crickets can sometimes be killed in the garden at night by the combined use of an electric torch and a quick stamp with the foot which crushes them before they are able to retreat down their holes.

Locusts, on the other hand, are so numerous that no really effective method of controlling them has yet been devised.

Mole-crickets and locusts are attracted to poisonous baits made up in the following proportions:

Sodium arsenite, 4 oz.

Horse dung, or fresh swamp grass chopped into 2-inch lengths, 25 lb.

Water, sufficient to moisten the mixture well.

A very high percentage can be killed in this way. With locusts, however owing to their widespread nature, a 100 per cent. kill in a small area has very little effect.

2. Typical Sucking Insects

These insects have a proboscis, or suctorial mouth-part which they thrust into the leaves, stems or fruits of plants to suck the juice, thereby weakening the plant.

(*a*) *Plant-sucking Bugs*. This is a whole group of insects which have sucking mouth-parts in both their mature and immature stages, and which do a great deal of harm to crop plants, sometimes by injecting poisonous toxins into the plant. Well-known examples of sucking bugs in West Africa are the cacao bark sucker *Sahlbergella* (*Sankonuabe*-Twi), the cacao 'mosquito' (*Helopeltis*), and the cotton stainer (*Dysdercus*). The red cotton stainer is probably the best example of such a bug, and all those living in cotton-growing districts are familiar with this insect and the damage it does to cotton bolls. If very immature bolls are attacked they are shed, older bolls ripen prematurely, and produce useless lint, whereas bolls attacked just before opening appear stained later, owing to the presence of boll disease in the fully formed lint. No staining occurs from cotton stainers after the bolls have opened although staining may occur during ginning on account of insects being crushed.

(*b*) *Scale Insects, Mealy Bugs, and Aphids*. (These are degenerate families of plant-sucking bugs.) Scale insects are generally small and degenerate, each living under a shell or scale which serves to protect it from the weather and from enemies. These scales can be seen in great numbers either on the under-surface of the leaves, as on the coconut palm, for example, or on the stems of trees such as citrus fruits. Scale insects often seem to live in partnership with various kinds of ants which are attracted by the sweet juices excreted by the scale insects, while serving at the same time to protect the scale insects from their enemies. Therefore when streams of ants are seen on a plant or tree, it is often an indication that scale

insects are present and a careful examination will soon show where they are. Such ants are generally blackish in colour, although the common red tree ants or weaver ants also encourage scale insects which happen to be harmless to the farmer. At the same time they are the farmer's friend in that they keep noxious insects away from the tree, in the leaves of which they make their nests.

If one of the scales is picked off with a knife or with the finger-nail and laid upside down and examined carefully, preferably with a hand lens, the small and helpless scale insect can be seen within its shell. These insects suck the juices from the stems and leaves of their hosts and often weaken them so much that the plants are killed.

Scale insects affect the plant in the same way as all other suctorial bugs, but less so in proportion to the numbers present, as they do not inject poisonous substances into the host plant.

'Mealy bugs' and aphids are also rather primitive or degenerate types of insect. Mealy bugs are similar to scale insects in many respects and have a white mealy or woolly appearance and are sometimes found on the tender shoots or leaves of plants. The aphids or 'plant lice' are generally small and wingless and suck the juice from the tender growing-parts of plants.

(c) *Fruit-piercing Moths.* Although most butterflies and moths have long and slender sucking mouth-parts known as proboscises, with which they suck the nectar from flowers, some moths are specially adapted for sucking fruits, citrus fruits in particular. Some of these moths have specially hardened points on the proboscis or mouth-part with which they are able to pierce the thick skin or rind of a grape-fruit or other citrus fruit and suck the juice within. The fruits generally attacked are those which have already ripened on the tree, and the hole which the moth makes in the rind generally causes the fruit to rot in the neighbourhood of the injury, after which it soon falls to the ground partially rotten and useless for human food. It has recently been found that if such fruits are picked from the tree *just before they are ripe*, and stored in wired fruit houses before sale a considerable amount of damage can be avoided.

It is obvious that these sucking insects cannot be killed by arsenate of lead and similar stomach poisons, as they push their sucking mouth-parts deep down into the tissues of plants to suck the prepared food in the sap. It is clearly impossible to

poison this sap without poisoning the plant as well, so that another method of attack must be used. This method is the use of what are known as 'contact poisons', that is, poisons which kill these insects when they come into contact with them. All the insects must be covered if they are to be destroyed, and this is often difficult to accomplish. Some insects find protection in crevices in the bark, in buds, and in other places where the spray cannot reach them. Scale insects have protective coverings which fit tightly to the objects on which the insects feed. Contact poisons must therefore be strong and penetrating. Such insects are therefore killed by suffocation, or cutting off their air-supply as well as by the penetrating effect of the poisons. As insects, including scale insects, breathe through tiny holes or 'spiracles' the object is to stop up these breathing holes so that the insects cannot get air. This can be done very effectively by the use of a certain mixture known as kerosene emulsion. This is prepared with soft soap, water, and kerosene in the following proportions.

Half a pound of soft soap is cut up into small pieces and thoroughly mixed up with 1 gallon of hot water. It is then removed from the fire and 2 gallons of kerosene are added and the mixture is stirred vigorously until it emulsifies. The soap breaks up the kerosene oil into tiny globules, forming what is known as an emulsion. This is kept as the stock solution and should be mixed with six to ten times its volume of water and stirred again before it can be used. Sufficient stock solution should be made for early use, as when it is allowed to stand free kerosene separates out and will burn the foliage when it is applied. Kerosene emulsion should be applied only in the early morning or late afternoon, owing to the tendency for it to burn the foliage when the sun is up. It has the effect of clogging up the breathing holes so that the insects are soon killed and drop off. The soap film cuts off the insect's supply of air and the kerosene also undoubtedly helps to kill the insects by its penetrating properties and its strong odour. Soap solutions of this kind are particularly useful for the smaller and more delicate types of insects.

Other types of contact poisons are the insecticides which are made from tobacco. These preparations, which are sold under the name of nicotine compounds, are manufactured mainly from the waste products of tobacco and cigarette factories. This waste material consists mainly of the stem and midribs of

tobacco, which are richer in the poison known as nicotine than the leaves themselves. These nicotine compounds are sold under various names, nicotine sulphate, for example, being one of the chemical compounds, and being more effective than kerosene emulsion. It is made by boiling 6 gallons of water with ¼ lb. of hard soap, after which 1 oz. of nicotine sulphate (40 per cent.) is added and it is allowed to cool before using. It acts as a poison, entering the spiracles of the insect and is one of the most effective contact insecticides.

Resin emulsion, made in the proportions of 2 lb. of powdered resin, 1 lb. of washing-soda crystals, and water enough to cover them, and boiled until they form a clear yellowish liquid, is another effective insecticide and kills by suffocation. This stock solution is diluted with 6 to 10 gallons of water before use.

An emulsion of this kind forms, on drying, a kind of varnish over the insects with which it comes in contact, thus preventing them from breathing.

3. Other Pests

On land which is kept continually cropped another type of pest sometimes causes considerable damage. This is the eelworm, a small thread-shaped worm which bores its way into the roots of crops, particularly European vegetable crops such as carrots, turnips, cabbage, and the like, which have been grown for some time on the same land. Although, strictly speaking, an eelworm is not an insect, its method of treatment is similar to that of insects, so that it is mentioned here. The irritation caused by these worms in the tissues of the roots causes them to become enlarged and covered with swellings of all shapes. One cure for eelworm infection is to avoid growing the same crops more than once on the same piece of land, or by practising rotation. As other crops and cover crops are not necessarily immune from attack, it is better to give the land a complete rest for a year or two. If the land is not allowed to grow weeds, but is put under bare fallow and kept dug up so that the sun and air get into the soil, the eelworms die of starvation. If quick-lime is also added, they are destroyed even quicker, as they thrive best in sour land on soils deficient in lime.

Insect Friends of Man

While insects such as the 'silkworm', lac insect, and honey-bee are direct friends of man, other insects are his indirect friends because they prey upon insect pests of crops.

All insects have their own particular pests and enemies which either attack and eat them, or else live as parasites on them. Types of lady-bird beetles are probably the best examples of insect friends, and these tiny and beautiful beetles are sometimes seen on the underside of the leaves of coconut palms, as they live on the scale insects there. Not all lady-bird beetles, however, are friends of man.

Birds of course often do a great deal of good for the farmer by destroying harmful insects. Some of the larger insects, such as the praying mantis, as well as digger- and mason-wasps, attack and feed on insects harmful to crops. Mason- and digger-wasps, for example, often capture caterpillars which are then stored in their clay nests as food for their larvae.

Another type of an insect friend is the so-called Ichneumon fly. This is a wasp, mainly distinguished by its narrow 'waist' and its long egg-laying organ or *ovipositor*, which is found at the end of its body. These wasps thrust their ovipositors into the soft juicy bodies of certain caterpillars, laying their eggs below the surface of the skin. As the eggs hatch, the larvae feed on the soft flesh of the caterpillar, and are therefore *parasites*. The caterpillars are soon weakened and generally die, whereas the wasp larva or larvae complete their life-histories in the caterpillar and finally emerge as full-grown wasps.

Some of the most useful of this group of internal parasites are minute wasps, which are too small to be seen by the casual observer.

One group of the two-winged flies are also important internal parasites, destroying their hosts in much the same way as the parasitic wasps.

Therefore insect friends such as the lady-bird beetles and Ichneumon flies should be encouraged, and so important are they, in fact, that Government entomologists in many countries are actually importing such insect friends of man, leaving one such type of insect to wage war on the other harmful type which man, by his own power, is often so helpless to deal with.

CHAPTER XXXIII

PLANT DISEASES

The majority of plant diseases are caused by microscopic fungi, others are due to bacteria and 'viruses'. These diseases are often most destructive and cause great economic losses, and even famine. Thus, the coffee-leaf disease in Ceylon in 1868–78 completely ruined the industry, and the cultivation of coffee all over the country had to be abandoned, resulting in a loss of 12 to 15 million pounds in ten years. Corn smut, the progress of which was fortunately arrested in the Gold Coast by prompt control measures, is in other countries, such as the United States, the cause of 20 to 30 per cent. loss of the crop in good years, and up to nearly 100 per cent. on some farms in bad years. Examples of damage done by plant diseases in West Africa are: Black Pod disease of cacao, causing on the Gold Coast an annual loss varying from 5 to 20 per cent., or on the average about 10 per cent. of the crop; Cassava Mosaic; Coco-yam Root-rot, a disease which has increased alarmingly of late, so that the cultivation of coco-yams is quite impossible in some large areas, and the local price has risen to as much as four times the normal price owing to the cost of transporting coco-yams from other districts.

Examples of fungi with which every one is familiar are the mushrooms, which are edible, and the similar and so-called 'toadstools' which are sometimes definitely poisonous. The umbrella-shaped organ which appears above ground is the fruiting body, and it produces in the 'gills' or pores on the underside of the cap vast numbers of spores, consisting of tiny dust-like particles which serve the same purpose as the seeds of flowering plants. However, unlike the seeds of flowering plants, they do not contain reserve food material and the great majority of them perish, so that the fungus plant produces them in vast numbers.

The vegetative part of the fungus is not so well known, for it consists of a widely spread network of thread-like 'mycelium', which spreads in all directions in the soil, or on the decaying wood on which the fungus feeds. The mycelium serves both as root and stem, and extracts nourishment from decaying vegetable matter in the soil. One of the threads of a mycelium is called a 'hypha' (plural—hyphae). Fungi, though they are

plants, belong to lower orders than the flowering plants and are not able to manufacture starch, as do green plants. They depend for their food-supply on starches, sugars, and other prepared foods which have already been manufactured by green plants.

Some of these large fungi cause plant disease, by attacking the tissues of living plants in their search for food. The majority of parasitic fungi, however, are very small, and can only be seen with the aid of a microscope. Nevertheless, they have the same characteristics as the mushrooms in that their vegetative parts are composed of mycelium, and that they produce spores, though the latter are borne on small fruit-bodies of a great variety of shape and structure. Examples of such smaller fungi which can just be distinguished with the naked eye are the often brightly coloured 'moulds' which so frequently cause the deterioration and decay of foodstuffs, leather, and other organic materials in damp conditions. 'Mealy pod' of cacao is an example of such a fungus disease. (Plate XXXII *c*.)

Any or all parts of the host plant may be attacked or destroyed by parasitic fungi. On the *leaves* the discoloured spots commonly seen for example on tobacco and ground-nuts are caused by fungi, which enter the leaves, often through the stomata, kill the cells, and live on their contents. Another familiar example of leaf disease is the 'White Thread' disease of cacao and cola, in which the white mycelium of the fungus can be seen growing along the twigs and leaf-stalks, and over the blades of the leaves, on which it spreads out into webs of fine white hyphae; the leaves are killed, and can be seen hanging on the trees in brown masses, held together by the fungus threads to which they are all attached.

The leaves of maize, Guinea corn, and other cereals are very commonly attacked by 'rust' fungi, which cause red or brown spots and stripes of a rusty appearance. The importance of leaf diseases lies in the interference with the normal work of the leaf, which is the manufacture of starch, thereby weakening the plant.

On *stems* and *branches* a common type of disease is 'canker' which causes a spreading rot of the bark. Cankers may become so extensive as to cause the death of trees and shrubs, owing to the food- and water-supply, which is conveyed through the bark, being interfered with. In cacao farms a common canker of the 'cushions' on the trunk is caused by the black pod fungus, which grows back into the bark through the stalks of diseased

pods. (Plate XXXII *b*.) This fungus not only destroys the cushions, but lives in the bark throughout the dry season, becomes active again during the succeeding fruiting season, and so helps to start a new outbreak of pod disease. A close examination of cacao trees in most farms will reveal the presence of vertical cracks below many of the cushions. These cracks are the cankers. If the outer bark is cut off with a sharp knife, it will be found that the inner bark is diseased, and of a bright purple colour. The damage may extend to several inches below the cushion, and in neglected or badly situated farms the whole of the bark of the trees may be destroyed.

Another stem disease is 'wither tip' of cassava. Here the fungus attacks the juicy young shoots which grow during the rains following a dry spell. The shoots die back, wither, and dry up quickly. As they die the fungus grows thickly under the outer skin of the stem, forming numerous light-coloured spots. Over these the skin splits, allowing little pinkish masses, each consisting of millions of tiny spores, to escape. The spores are scattered far and wide by the wind, as well as by insects, and so the disease is spread.

The *fruits* of plants are often well supplied with sugars and other food substances on which fungi thrive, and are therefore very liable to attack. An example of a fruit rot is the well-known 'black pod' disease of cacao. (Plate XXXII *a*.) The diseased pods turn brown, and later black, owing to the death of the flesh, on the juices of which the fungus feeds. The parasite, having thriven at the expense of its host, produces spores on the surface of the pod. These spores may be seen on damp mornings as a greyish film, or sometimes as a rather mealy, pinkish-brown powder on the surface of the pod. The spores are carried to new pods in drops of dew or rain, on the feet of insects, and even on the hands, tools, and clothing of farmers. When the spores find themselves on healthy pods, and in suitable damp conditions, without which they cannot grow, they germinate, and the hypha of the fungus-plant bores its way through the epidermis and into the flesh of the pods. The new fungus plant then grows rapidly among the cells of the flesh, kills them by means of poisons, and feeds on their sap. Countless millions of spores are produced on each diseased pod, so it is not surprising that, in wet weather, outbreaks of disease spread very rapidly, and that in a short time as much as half of the total crop of a farmer may become diseased.

The *roots* of plants are also attacked by fungi, frequently by those kinds which look like mushrooms and which are known by their tough fruiting bodies as 'bracket fungi'. Common examples of this type are 'collar crack' of cacao and 'white root' and 'brown root' of cacao, cola, rubber, and other trees. In these the fungus lives in the soil and attacks the roots of trees when it comes into contact with them. These fungi usually destroy the wood as well as the bark, and quickly kill the tree. Infection is spread by contact between the interwoven roots of the diseased tree and its healthy neighbours, so root diseases of this kind usually spread quickly in circular patches radiating from the first case.

The very disastrous root-rot of coco-yams is a good example of a root disease of a field crop. Here again the causative fungus lives in the soil, and attacks and kills the roots as they grow out from the underground stem. The underground stem itself is not affected, but the food-material stored there is quickly exhausted in the effort to support the young shoots and in the continually renewed efforts to form a root-system, so the young plant soon becomes exhausted and dies.

The minute organisms known as bacteria also cause plant diseases and work in a similar way to fungi, being transmitted in the form of spores or dried cells by air currents or on tools or by insects.

Another type of plant disease is that caused by 'viruses', which cause very serious losses all over the world to growers of cassava, sugar-cane, tobacco, ground-nuts, cotton, and many other valuable crops. In West Africa two important examples are cassava mosaic and cotton leaf-curl.

A virus consists of a very simple and minute organism which cannot be seen even with the aid of a powerful microscope, but which can be detected in the laboratory by other means, too involved to be described here. They are usually spread by insects such as aphides which suck the sap of plants. These insects carry the virus in their mouths after feeding on diseased plants, and when they thrust their proboscises, or 'beaks', into healthy plants they infect them with the virus. Infection can also be spread by the knives used for making cuttings, in grafting, and sometimes on the hands of growers when they handle and slightly bruise the foliage. The virus multiplies in the sap and is carried by it all over the plant. Once the plant is infected, it cannot be freed from the disease, which is present in all

cuttings obtained from the parent plant. The common symptoms of virus disease are stunting, leaf deformities, such as crinkling; and pale areas on the normally green blade of the leaf, often in a sort of pattern, hence the name 'mosaic'. The crop of roots or fruit is greatly reduced, and in severe cases the diseased plants are so stunted as to be dwarf growths which produce nothing.

Another type of disease is not caused by parasites, but is due to disturbances in the normal function of the plant, such as of starch formation, respiration, and water-supply. These disturbances are due to certain conditions in the surroundings of the plant, such as those which are produced by faults in cultivation. A common example of such a disease is the 'blossom-end rot' of tomatoes, a disease in which the end of the fruit dies, forming grey and wet, or black and dry sunken areas of rot. This disease is due to an unsuitable and irregular water-supply, and such diseases are mainly called 'non-parasitic'.

There are two methods of protecting plants against their fungus and other enemies. First the state of health of the host plant must be considered. Strong, healthy men are less liable to disease than those in poor health, or if they do contract a serious disease they are more likely to recover from it successfully. The same is true of plants. Crops must therefore be grown under healthy conditions, in suitable soil, and with proper water-supply. Some plants should be protected from sun and wind and given such cultivation as they need. It is sometimes necessary to dig drains to prevent stagnant water from lying close to the surface of the soil, as badly drained soil is a condition particularly favourable to disease. Hoeing the soil also helps to aerate it and keep it healthy, while to mulch or manure it to make up for deficiencies of plant food helps the crop to grow normally and well. It is important to pay attention to *sanitation*, which plants need on the farm just as much as men need it in the towns. This means that all dead and diseased plant refuse, such as diseased cacao pods and the wood of diseased trees should be destroyed, either by burning or burying. The wounds of trees caused by pruning or by branches being blown down by wind should be dressed. Coal-tar is sometimes applied and is better than nothing, although often it is injurious to the bark itself and should only be used if nothing better can be obtained. If exposed wood or bark is already diseased, as for instance with cankers, all the diseased parts must be cut away

and the wounds trimmed up so as to permit new bark to be formed. The best method is to wash the wounds with a disinfectant, such as 'Agrisol' (soluble Solignum) and then paint with coal-tar, or even better with white-lead paint, to protect the exposed wood from fungi which would certainly attack it if it were not treated, and eat away large cavities in the trunk or branch.

These 'indirect' methods, as they are called, aim at creating healthy conditions, and so increasing the plants' vigour and decreasing the chances of their contracting diseases. They form part of the ordinary programme of cultivation in well-managed farms, and in the Gold Coast are more important than is usually recognized. It has been said that cacao diseases would be negligible if cacao trees were always planted in suitable land and given proper cultivation. Such methods of prevention are better than any attempt to cure disease.

The second method of protection is the 'direct' method, by which measures are taken directly against the fungi or other parasites by artificial means. Direct control consists in the use of chemical mixtures which are poisonous to the parasites but do not damage the host plants. Such mixtures, which usually contain copper salts or sulphur in some form, may be sprayed on to the plants as fluids, or dusted on in the form of a fine powder, or they may be applied to the soil in the case of root diseases.

Sprays or dusts cover the surface of the plants with a thin coating of substances which kill the fungi before they can penetrate into the tissues. When 'soil drenches' are used, the poisons remain in the soil for a long time and prevent the growth of the harmful fungus in the neighbourhood of the roots.

Examples of direct control tried out successfully in the Gold Coast are the use of 'Shirlan' spray against tomato leaf-mould, and 'Cheshunt Compound' against coco-yam root-rot. These are economic controls, which well repay the expense of application. Unfortunately, it is not always economical to use direct methods; spraying against cacao pod disease, for example, costs more than the value of the crop saved. Therefore, with cacao-pod disease, as with so many other diseases of crops, 'prevention is better than cure'.

Another useful method of direct control is the disinfecting of seed, especially of some cereals, which carries spores of fungi. The seed is either soaked in a fungicidal solution, or shaken up

with chemical dusts. Corn smut, for example, can be prevented from spreading by soaking the seeds in a solution of 'blue stone' or copper-sulphate, which kills all the spores present.

It must not be supposed that direct control is a simple and easy alternative to indirect control. It is used *in addition* to the care and cultivation normally involved in agricultural practice, without which it loses most of its value.

There are some diseases, notably the virus diseases of which cassava mosaic is a good example, which cannot be controlled by any of the methods already described. In such cases there is yet another means of defeating the parasites. By careful selection of individual plants which seem to be more resistant to the disease than their fellows, and breeding from such plants by artificial fertilization, it is possible to produce strains of cassava plants which are immune to the disease, that is plants whose sap includes substances which do not allow the virus to thrive and multiply. This method is now very extensively and successfully used, and is being applied in West Africa and other countries to the problem of preventing cassava mosaic.

CHAPTER XXXIV

SCHOOL GARDENING[1]

As this book is written largely as a reference book for teachers it was thought advisable to put in one chapter on school gardening. In some ways the whole book deals with school gardening, with the soil and its improvement, with the crops, their rotation, and propagation, and with the main ways of treating their insect pests and diseases. Therefore this chapter is mainly on the 'teaching method' of a subject, which, if taught badly, can be both boring and useless, but, if taught well, can be one of the most useful and inspiring subjects in the school curriculum.

First of all, a good teacher of school gardening requires two things; a thorough training and experience in the principles and practice of agriculture, and, secondly, a great desire to impart his knowledge and enthusiasm.

In many schools, either the school garden has become very poor and neglected, or monotonous in its routine, or else the school, particularly if it is a town school, does not possess a garden at all. Either of these positions may offer great opportunities to a keen teacher. Much of the interest in school gardening comes in putting a neglected and derelict garden into shape or in laying out and planning the garden for the first time. If a new garden is to be made, one of the first considerations is the selection of a suitable site. This should be as near the school as possible and the ground should be level, as otherwise the difficulties of dealing with soil wash or erosion will be so great that part of the garden may be in danger of ruin in the heavy rains. When possible extremes of soil conditions should be avoided. Soil that is too sandy or too clayey should be avoided. When the land is to be divided into equal plots it is unfortunate if some plots consist of ant-hills, or gravel only, or of swampy hollows. Where this cannot be avoided beforehand, the ground should next be cleared and levelled off as far as possible, ant-hills, stones, and the like being used for making paths, while the soil removed from the paths can be put on the plots where the soil is poor or uneven.

[1] The reader is recommended to read G. H. Eady's article on 'School Gardening' in the *Gold Coast Teacher's Journal* (1931–2). Besides giving general instructions as to choice of site, preparation, lay-out, &c., lists of suitable garden plants are given with botanical, common, and vernacular names (when known) as well as the rainfall requirements of each.

It is easier when the garden is either square or rectangular in outline as the plots can then be made of equal size, and the whole garden looks neater. The teacher should decide on the number of plots the school requires, the number of children per plot, and the size of each plot. It is best to do all this on paper first, drawing the plan to scale. Sometimes it is necessary to alter one's original plan somewhat, to suit circumstances, such as the amount of land available.

A base-line is then cleared and marked out with pegs. A surveyor's chain is invaluable for laying out a school garden, but, failing that, a large tape-measure and a long strong piece of cord are necessary.

Short pegs are driven in at the required distances, one child standing beside each peg and the teacher lining them up before the pegs are driven in finally. The other three lines are measured off, and then, with a child at each of the four corners of the whole garden, the teacher can decide whether the shape is a square, rectangle, rhombus, or parallelogram. If the two latter, he then moves his corners until all four angles are right angles. As it is practically impossible to judge a right-angled corner by eye only, the following method, known as the '3, 4, 5 method', is used. A single piece of rope is taken and marked or knotted at three, four, and five feet (or yards if necessary). A child holds each knot or mark; the last knot being brought round to join the beginning of the rope, thus forming a triangle. The angle between the 'three' or 'four' sides should be a right angle, the 'five' side being the hypotenuse. (Cf. Pythagoras' problem in Euclid whereby in a right-angled triangle, the square on the hypotenuse equals the sum of the squares on the other two sides, i.e. $3^2+4^2 = 5^2$.) The remainder, the division of the sides and laying out of cross lines, is simple, but requires careful supervision of the positions of the children before the pegs are finally driven in.

The next most important point is to hedge in the whole garden, to keep out intruders, such as sheep, goats, pigs, and poultry, as well as wild animals. There are many different plants suitable as hedging, just as there are many types of soil, climate, altitude, and rainfall in West Africa, so that to give details of all suitable hedge plants is not possible. Further details of the best shrubs to be planted can be obtained from local officers of the Agricultural Departments.

It is best if a trench 3 feet deep and 2 feet wide is dug and

filled with black soil, and if possible compost, before the hedge is planted. The main requirements of such hedge plants are that they should be quick-growing, impenetrable, and evergreen. *Cassia siamea* is often used for the purpose, but is such a vigorous feeder that it uses up much of the food from the plants round the edge of the garden. In some places, thorny and succulent plants, such as prickly pears and thorny *Euphorbias*, are used. Although these are most effective in keeping out animals they tend to become pests, are apt to impoverish the soil, and are difficult to get rid of. Thorny shrubs like Madras thorn, Jerusalem thorn, Logwood, *Carissa edulis*, Lime, and others are more suitable and more beautiful, whereas if the garden is not troubled by animals, shrubs such as *Hibiscus* or shrubs with coloured foliage like *Acalyphas* or *Crotons* could be used. Such hedges when planted need constant care and pruning to keep them a good shape.

Wherever possible, however, permanent fences made of wire-netting or lattice-work should be used and another fence, consisting of some suitable and beautiful flowering shrub planted inside to hide it. Sometimes effective fences made from split bamboos, or the split rachis of oil or raffia palms, are used, but they are generally attacked by termites or 'white ants' and need repairing and replacing.

After the plots have been properly lined up and hedges planted, care should be taken to provide footpaths between the plots. There should be two large and main footpaths across the garden in both directions with small paths leading away from them, and smaller paths between the plots themselves. Such footpaths ensure that children do not walk over each other's plots, hardening the soil and trampling young seedlings with their feet. Such paths should be kept thoroughly weeded, the owners of the adjacent plots being responsible for their upkeep.

The number of children per plot and the size of each plot vary according to the age of the children. Generally speaking, children under 12 are mainly interested in observation and appreciate variety, whereas those over 12 are more serious and are old enough to understand the reasons for such processes as crop rotation.

Very small children of kindergarten age love to plant and see things coming up, but are inclined to forget about their plants at times and have no idea how to plant in an orderly fashion. It is worth while devoting a special piece of the garden to them,

where they can plant anything that interests them and that they want to see grow. With older children of primary age an attempt should be made to keep proper plots and to plant their crops as far as possible in rows. Even at this age children like to play, but will work in spasms on rainy occasions and when there is anything to plant. They learn to handle tools and can be taught the use of new tools such as the rake. They are inclined to dig up prematurely such crops as ground-nuts to see how they are getting on. They also like to plant flowers or any other plants which interest them, and they should be encouraged to do so, provided that they plant the seeds and plants given to the class first, and also that they keep their gardens neat and tidy. Some feel that children of 10 to 12 years of age should work in groups or even in pairs. In many school gardens such 'communal' plots are kept and the children work in groups, often looking after only one crop in a rotation. While this method often results in the large rotation plots looking tidy, it often does not really interest the children. The children's education must always be considered first, however, and the main purpose of the school garden is to interest children in Nature and in growing plants, and not merely in the production of a neat, spick-and-span garden to impress the outsider. Of course every effort should be made to get the children to keep their plots as tidy as possible, but the main purpose of the work is to make and keep them keen and interested. When this happens the teacher becomes less and less of the taskmaster and more of the keenly interested friend. Therefore, when possible, it is good to allow even children under 12 to work in pairs rather than in groups, and if individual children seem to prefer to work alone on their own plots, they should be encouraged to do so.

From the ages of 12 to 14 or over the children should, whenever possible, be allowed individual plots, Children or students generally work much better when each is allowed a garden of his or her own. The older ones should be required to plant certain crops on a definite plan, drawn up by an expert and suitable for the district, but some allowance should be made for the individual teacher to use his own discretion as to the actual crops to be planted according to the seeds available and other local conditions. Similarly, the teacher, while getting every boy or girl to carry out the general scheme of planting, should leave some room for individual initiative and should allow and

encourage the children to try small experiments on their plots or to try out different varieties of crops or even a few plants of crops new to that district. Wherever possible such experimental and individual work should be the result of the child's own ideas, helped by the teacher. If children lack ideas they should be encouraged to think of some, or if they are particularly dull, the teacher may suggest suitable simple experiments to them.

The ground should be thoroughly prepared in the dry season, all stumps of trees and shrubs should be dug out and burned, and the ground dug as deeply as possible and all lumps broken to make a fine tilth.

It is important for the success of the garden, first that the gardening period be arranged in the cooler part of the morning or afternoon, if possible, and also that allowance should be made in the time-table for exceptional periods such as those times after rain when it is so important to get crops planted while the weather is suitable. Such extra time is vitally important, particularly in dry regions where opportunities of planting are few and far between.

The tools required in school gardening are described already in another chapter, but it is important that they should be properly housed and looked after. Usually a store-room is set aside in the school building for garden tools, but when the garden is some little distance away it is advisable to have a special tool-shed in the garden itself. It can be made of swish roofed over with corrugated iron. There should be numbered hooks round the walls on which to hang the tools, and the door should be kept locked between class periods. Tools should be marked with a number which is either painted or stamped on the handle, or better still stamped on the tool itself. It is best if each student is provided with his own numbered hoe, of which an account is kept. If he loses it or breaks it through carelessness it can be charged against him.

The tool-store and tool-shed can also be used for the storage of seeds, yam sets, and the like, of which methods of storing are described elsewhere.

Care should be taken in the planting season to ensure proper selection of seeds and the planting of the right number of seeds at the correct depth and distance apart. If a more or less uniform system of planting is adopted, all plots have more or less the same treatment and can carry on the same general rotation.

The ground should be kept thoroughly weeded and cultivated,

especially in dry regions, where it should be kept in a fine state of tilth after each rain in order to conserve moisture.

In a special part of each rotation plot, or of one special part of the student's own area, space should be left for individual experiments with new plants or varieties. All kinds of simple experiments could be tried, either on individual plots, or some on some plots, and the opposite experiments on others. The following is a list of suitable experiments: (1) Distance of planting; (2) depth of planting; (3) seed selection; (4) single and mixed cropping; (5) cultivated and uncultivated areas; (6) deep and shallow cultivation; (7) manuring with wood ashes, farm-yard manure, and compost (such experiments require generally a year or more to show full effects); (8) dust and leaf mulching; (9) scrambling and staked tomatoes; (10) variety trials of food crops, and many others.

In the planting of school gardens, the teacher should take the season and the length of terms into consideration, as it is very disappointing when term finishes just before a crop like ground-nuts is ripe. Therefore the teacher has to know roughly the growing seasons of the various crops, and time his planting so that the short-season crops can be harvested before the holidays and the long-season crops can come into bearing during the following term. Sometimes it is impossible to do this, and the children have to harvest their crops in the holidays which is always an unsatisfactory arrangement unless the teacher can be present to see that justice is done. In boarding schools it is often impossible to arrange for fair harvesting during the holidays. Arrangements have also to be made to keep plots roughly weeded at least, and to prevent stealing.

Various methods are adopted of disposing of the produce. Generally the children are allowed part or whole of the crop, or some goes to the school kitchen or is sold and the proceeds put towards school funds. Sometimes some of it finds its way to the teacher's kitchen, but this is to be strongly discouraged. Wherever possible, business-like methods of disposing of the produce should be followed. If the students are allowed to keep or to sell their produce, they should also be taught that they owe something to the school, for the use of the land, tools, and tool-shed, the teacher's time and assistance, and also for the original seeds, cuttings, or yam 'sets'. If the teacher does not think it advisable to trouble about accounts, each child should at least return in kind what he received in the first place. Good yams,

and properly ripened, dried, and selected seed should be returned and kept in the school-store or tool-shed for the following season.

Where possible, however, the children should be encouraged to keep credit and debit accounts including the value of seeds and sets used, the amount received for the sale of their produce, and the amount charged against them for the breakage or loss of their tools. Such accounts teach them the value of their produce and labour as well as the value of money, and could be done during arithmetic lessons.

In their notebooks they should also keep accounts of their planting programme, plan of their plots, rotations used, distances, and dates of planting results, and as many other useful records as possible. This is a most important method that is too often neglected in the teaching of school gardening.

In most school gardens an area is set aside for a compost heap. All dead leaves and soft greenish stems, prunings of hedges and the like should be put on the compost heap which should be properly made and looked after. Woody stems should be burned and the ashes returned to the soil. Fuller details on the preparation of compost heaps are given in Chapter VII on 'Other Manures'.

Plots are sometimes set aside as nursery beds for propagating seeds and cuttings of decorative plants for the school compound. Special 'arbor' plots where shade or timber trees are grown, are sometimes seen. These are very useful, especially if combined with an 'Arbor Day' every year, when shade trees are planted about the compound or in the streets of the town, or when useful plantations of firewood or timber trees are planted.

Sometimes special flower-beds are made and look well, especially when near the entrance of the garden.

Various methods are adopted by teachers to keep a high standard in their school gardens. Some use a system of marking, allowing certain percentages for details such as spacing of crops, cleanliness and neatness of plot, depth of cultivation, and the like. Others encourage competitions and give prizes to the best plot-owners. Sometimes, inter-school garden competitions are held, and prizes given to the best school gardens. Although prizes and competitions are not the ideal solution, they often produce good results and stimulate interest in gardening, but if carried too far they may do more harm than good. Above all, every effort should be made to keep the students interested, and to educate them and to give them a love of the subject. This is

best imparted when the teacher himself is keen on gardening for its own sake.

Lastly, the school garden has endless educational values. It is also a centre for nature study, and if a Nature Calendar is kept, all that goes on in the school garden should be recorded on it. It can also be a centre for the production of leaves, flowers, fruits, and whole plants for the drawing lesson and even for clay-modelling. In geography lessons, the climate, rocks, and soil of the district can be studied with special reference to the garden.

The girls can obtain material from the school garden for their cookery lessons, or can use the plants for other purposes, such as for the extraction of starch from cassava or coco-yam 'roots'.

Attempts can also be made to keep a small museum in the class-room with objects collected from the school garden such as types of rocks, subsoil or soil, seeds of the various crops and crop varieties, insect pests of crops, and crop produce such as fibres, oils, starches, and similar products.

Sometimes it is possible to organize a little show of garden produce, where the best produce grown is exhibited and where parents and friends are allowed to come. Such miniature shows do much to generate interest in the garden, and are also useful ways of training children towards running proper agricultural shows in their own districts when they grow up.

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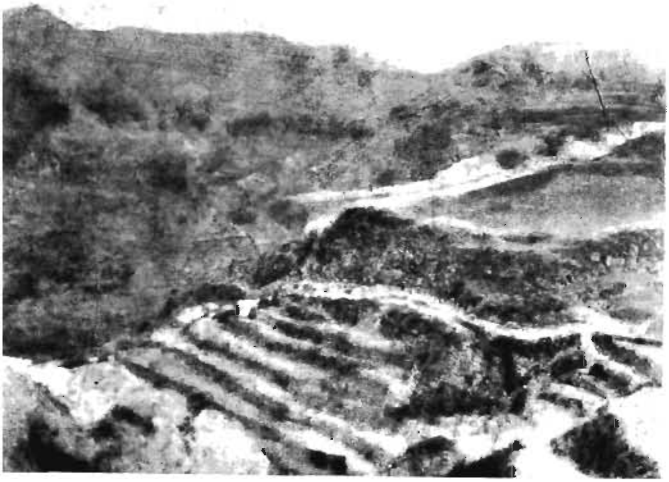
(a) *Inter-cropping. Lablab beans between young coconuts. Achimota Farm*



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(a) *Ridging of land to prevent erosion. Note double handed hoes and small dams left at intervals down the furrows*

(b) *Ploughing with oxen at Pong Tamale, Northern Territories, Gold Coast.*

(a) *Shelling corn. Southern Nigeria*

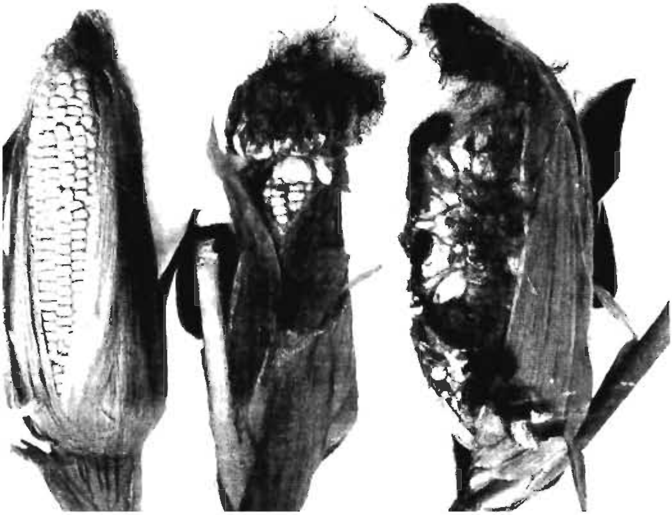


PLATE IV

Harvesting of rice in Sierra Leone

General view of rice farm with platform from which rice-birds are scared. Note other crop-plants growing amongst rice. Sierra Leone

(a) *Drying heads of Guinea corn. Gold Coast*

(b) *Hausa woman thrashing Guinea corn*

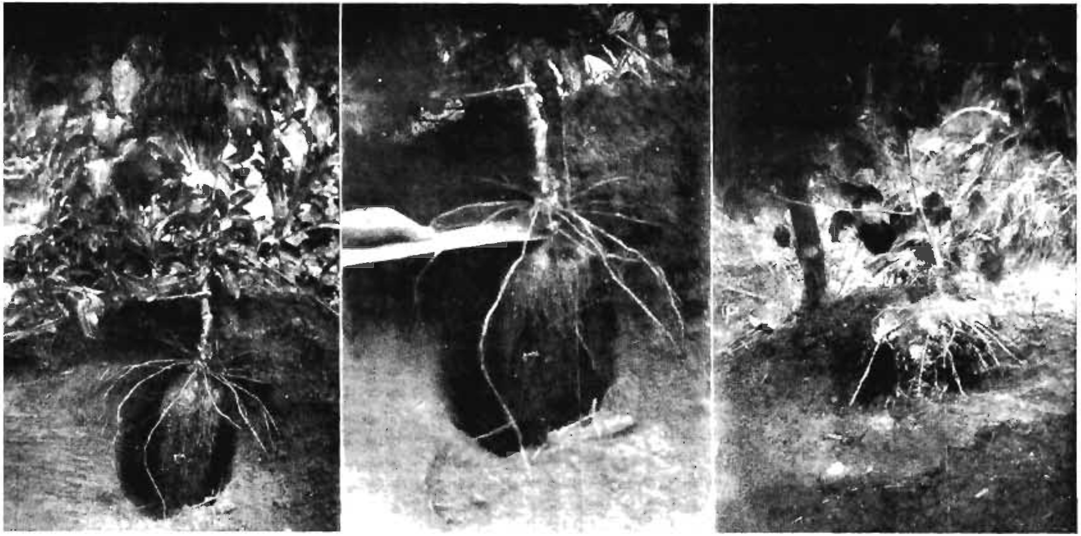
(a) *Bulrush millet. Women winnowing millet: woman thrashing millet in background. Tamale, Gold Coast*

(b) *Thrashing seed of Acha grass* (Digitaria). *Tamale, Gold Coast*

PLATE VIII

(a) *Making yam hills. Northern Territories, Gold Coast. Note the special type of hoe*

(b) *Breadfruit* (Artocarpus incisa). *Propagation by root suckers.* [illegible]

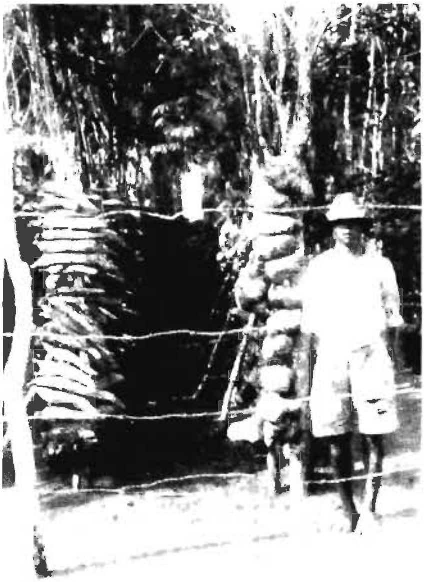


Stages in the propagation of yams

(a) *Soil removed to show yam*

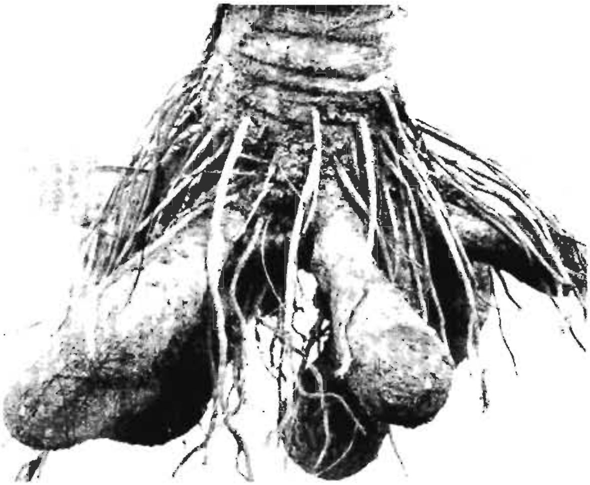
(b) *Method of cutting away tuber, leaving only a small 'crown'. Main portion used for food*

(c) *Small crown several weeks later, having grown into 'seed' yam used for propagation in the following season*



(a) *Ibo method of storing yams on racks. Umuahia, Southern Nigeria*

(b) *Side view of racks for storing yams. Note living poles with leafy growth providing shade. Umuahia, Southern Nigeria*



(a) *Corm of* Xanthosoma *coco-yam showing flask-shaped cormels*

(b) *Cormels produced round base of corm of* Xanthosoma *coco-yam*

PLATE XII

(a) *Teasing cotton lint before spinning*

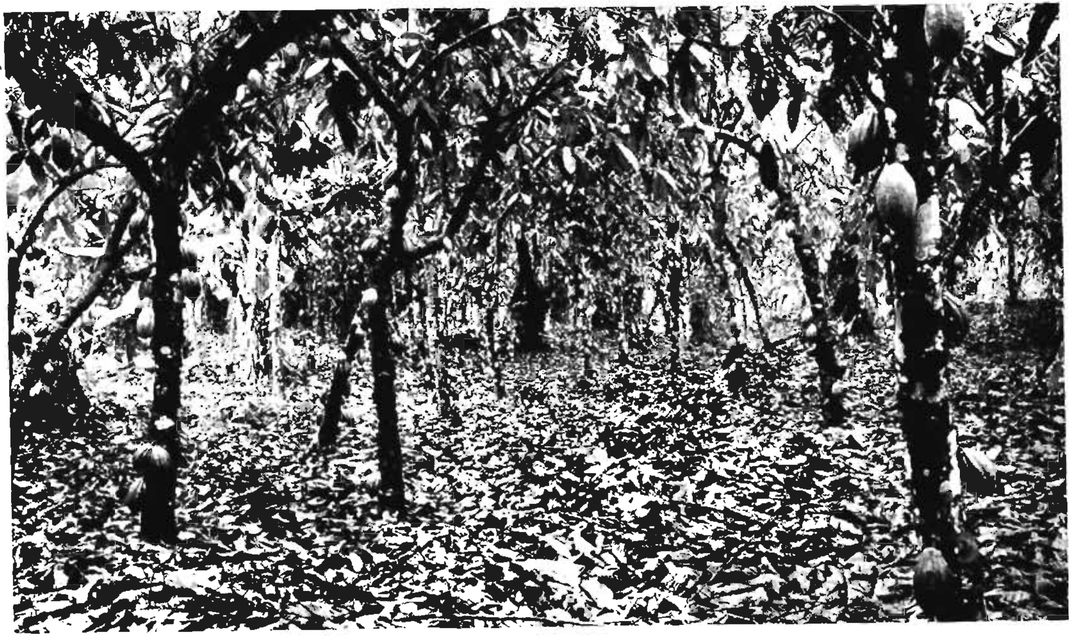
(b) *Carding cotton. N'jala, Mende district, Sierra Leone*

(a) *Wrapping cotton on spool after carding*

(b) *Spinning cotton from spool by twisting motion of fingers. N'jala, Mende district, Sierra Leone*

(a) *Weaving cotton cloth in narrow strips on African loom. Ashanti, Gold Coast*

(b) *Baling cotton. Northern Nigeria*



Cacao plantation. Gold Coast

Breaking cacao pods and removing beans. Gold Coast

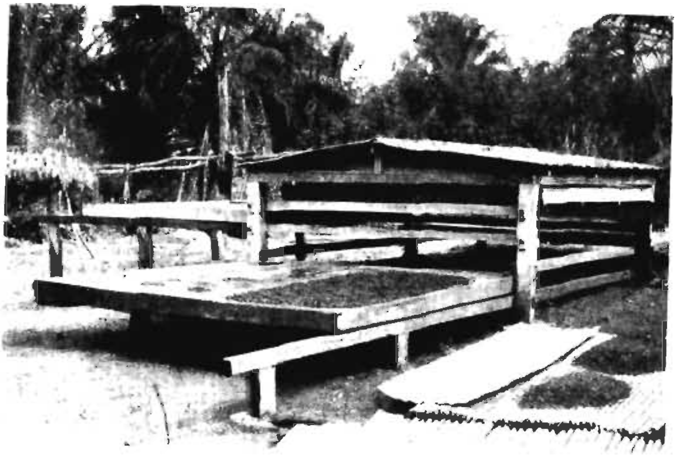
(a) *Stirring cacao beans in fermenting box. Gold Coast*

(b) *Cacao drying screens. Gold Coast. These are pulled out in four directions and can easily be slid back under cover*

PLATE XVI

Breaking cacao pods and removing beans. Gold Coast

(a) *Stirring cacao beans in fermenting box. Gold Coast*



(b) *Cacao drying screens. Gold Coast. These are pulled out in four directions and can easily be slid back under cover*

LATE XVIII

Liberian coffee in bearing. Gold Coast

PLATE

Robusta *coffee tree in fruit. Gold Coast*

(a) *Oil palm forest (uncultivated). Gold Coast*

(b) *Cutting fruiting heads of the oil palm. Gold Coast*

(a) *Boiling palm oil. Gold Coast*

(b) *Cracking palm-nuts and removing kernels. Gold Coast*

(a) *Planting coconuts. Gold Coast*

(b) *Coconut nursery. Gold Coast*

(a) *Splitting coconuts, Gold Coast*

(a) *Copra-making oven at Atwabo, Gold Coast*

(b) *Removing kernels of coconuts and placing on trays ready for the copra-making oven. Gold Coast*

(a) *Shea nuts growing*

(b) *Boiling shea nuts and skimming off the butter*

(a) *Orange tree dying from Gummosis, Aburi, Gold Coast*

(b) *Grape-fruit tree budded on sour orange stock, bearing fruit after 3 to 4 years. Aburi, Gold Coast*

PLATE XXVII

(a) *Bottom of trunk of a citrus tree showing effect of Gummosis, and sour orange seedling planted round base of tree before inarching*

(b) *Canary banana*

(a) *Male papaw tree*

(b) *Male papaw tree bearing small fruits*

(c) *Female papaw tree*

(a) *Fluted pumpkin* (Telfairea)

(b) *Pumpkin plant in flower. Sierra Leone*

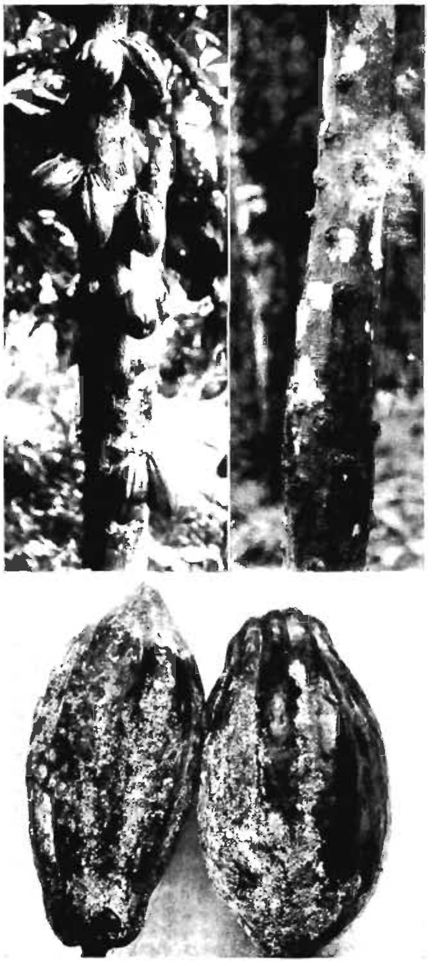
(a) *Harvesting ground-nuts. Nigeria*

(b) *Stack of ground-nuts on raised platform before beating and thrashing. Gambia*

(c) *Yam bean* (Sphenostylis stenocarpa). *Gold Coast*

(a) *Planting rhizomes of ginger. Sierra Leone*

(b) *The planting and weeding of ginger by Mende farmers (Sierra Leone). Notice narrow type of hoe used in the gravelly soil between the closely-growing plants*



a b

c

(a) *Black pod disease of cacao*

(b) *Canker of cushions and trunk of cacao tree following black pod disease.*

(c) *Mealy pod of cacao*